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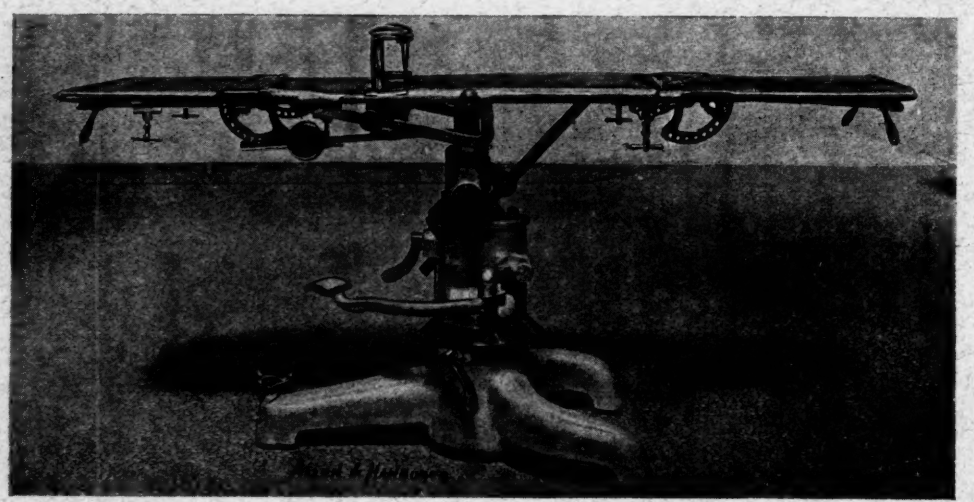

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JOHN MOYLE.

ONE OF HER MAJESTIES ANCIENT SEA-CHIRURGIONS.

DIED 1714.

EVEN as late as the end of the seventeenth century there was no well-defined line of demarcation between the naval and military services. Men like Monk would command a fleet at sea as readily as they would direct an army ashore. Most of the surgeons, like the executive officers, had seen service by sea as well as by land.

Not the least interesting, as he was perhaps one of the last, is John Moyle, senior. Of the details of his life few remain, except those which can be gathered from his writings. He states that "I have had the honour to be a Sea-Chirurgeon for not a few years in the Royal Navy of England, and have been in most of the sea-fights that we have had with any nation in my time." He refers to his experiences in "the last Holland War" in 1673, and "before Tripoli and at Tangier" in 1676. He speaks of Newfoundland, and had visited many of the Mediterranean ports previously. In 1693, "being grown in years and not able to hold it longer in that imploy of surgeon I am by the government otherwise taken care for (God bless our Gracious Queen)." He lived at Westminster on his pension, and died in February, 1713–14, leaving a widow, one son, and two daughters. Moyle's claim to remembrance rests on his two works *Chirurgus Marinus or The Sea-Chirurgeon*, and *Chirurgic Memoirs*.

The *Sea-Chirurgeon*, first published in 1686 under the title *An Abstract of Sea Surgery*, reached a fourth edition in 1702. It is dedicated to "The Worshipful The Masters or Governors of Chirurgions-Hall, London," and is undertaken, "not that I think better of myself than of other Sea-Surgeons (for there are some who were my contemporaries in the Navy and in the Wars whose knowledge I esteem better than my own), but I write this because I see a necessity for it, and yet others have not done it; and (indeed) I have more leisure time now than others being I am (by Royal Benignity) acquitted the marine imploy and live ashore on Her Majesties assigned allowance." The preface is addressed to the "Most Ingenious Sons of Art, Junior Doctors, Chirurgions of England; Success. For as much as for many years I have practised in this noble Chirurgic art, especially at sea, in the Royal Navy of England; and, consequently, have acquired that experience, that you who are younger, have not as yet had the opportunity to attain unto, I thought myself obliged (being now provided for otherways) to impart unto you my Practice and Method in curing, to the end that by it you may arrive to be able Practists in this affair and that the sick and wounded may receive benefit by it. It was the saying of a learned man *Non solum natus nobis sumus*, etc. We are not born for ourselves alone; so now I have done what good I can at sea I aim in this work to do more for the good

of Her Majesties subjects and in so doing I still serve her Majesty. You may see by it that it was not collected out of other authors, howbeit, it contains the general practice of most Chirurgions (especially such as use the Sea) but it hath been my own practice and I wish it may be yours; for (you may assure yourself) it is not founded upon frothy notions but it is the product of real experiences."

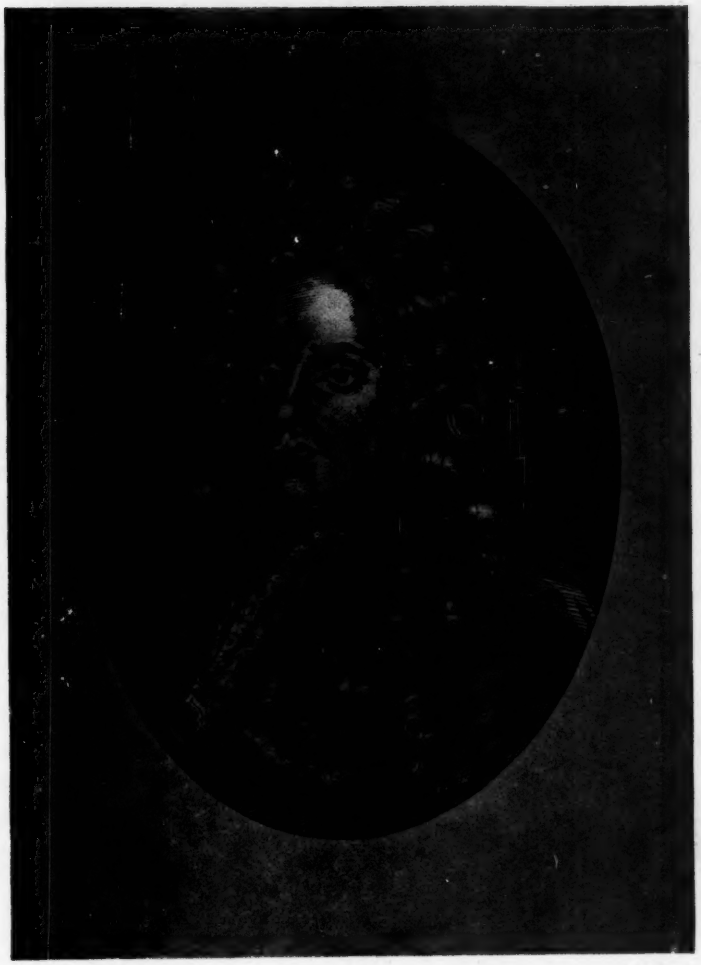
These characters give value to the book, which is dated "Westminster the 10th April 1702"; for John Moyle, senior, if he was not a good classic, was a capable and practical surgeon, devoid of imagination, and intent only on describing what should be done under the conditions of naval service to which he had been accustomed. A vein of simplicity, reminding the reader of My Uncle Toby, runs through the work, and his publisher, Eben. Tracy at the Three Bibles on London Bridge, induced him to advertise a nostrum called the Balsam of Chili, "which is only to be had of Eben. Tracy Bookseller at 1s. 6d. the Ounce. The bottles are all seal'd with the Balsam Tree."

Apart from this small trait of a commercial spirit, Moyle is eminently practical. He deals first with the medical aspect of life on board ship, giving details of the medicines needed to furnish the medical chest. This part concludes, "And being on board see that your dressing box is furnished. That is to say a box with six or eight partitions in it and a place for plaisters ready spread. In the partitions you put your pots and glasses of Balsams and oyls for present use. Now this box as well as your pocket instruments must be carried every morning to the Mast between decks, where our Mortar is usually rung, that such as have any sore or ailment may hear in any part of the ship and come thither to be drest. But such as by reason of illness cannot come thither, you must go to them where they lye."

The second part deals with surgery, and amongst other matters of importance "sheweth the Sea-Chyrurgeon how to prepare for a Sea-fight. I will imagine that you are now at sea in a Man of War and in sight of the enemy and all men are clearing their respective quarters and fitting themselves for fight, at what time as you are Chyrurgion of the Ship you must prepare as followeth.

"First, see that your Allop or Platform be laid as even as possible with a sail spread smooth upon it, which you must speak to the Commander to order. In Merchant men the Chyrurgeon's place is usually in the Cable Teer between Decks, but in Men of War 'tis in the Hold abaft of the Mast between that and the Bulk-Head of the Cock-pit from side to side. In this place you must have two chests to set your wounded men on to dress them. And at the corner of the platform you are to place two vessels, one with water to wash hands in between each operation and to wet your dismembering bladders in and for other services, and the other to throw amputated limbs into till you have opportunity to heave them overboard.

"You must likewise place good store of lights about the platform, in Lanthorns, but two of the largest (without Lanthorns) in the place where you are to operate. You must have there in readiness your instruments both large and small and your first intentions must now be there ready with your restringent powders, rowlers, linnen, cross bolsters, tow, acetum, ova, broad tape to make ligature and narrow to bind on splinters (for



JOHN MOYLE

apparel for fractures must not now be missing). Also basons to mix your restrictives in, pannikins to warm your oyls in and to dissolve your cerots (which can be done over your large candles). Have likewise your cordial bottle ready at hand to relieve men when they faint.

" And your surgery chest must not be far from you lest you should have occasion for anything therein—as the Traumaticks or other Vulneraries. And now being thus accommodated you are in a competent readiness for wounded men when they shall be brought down."

He then considers the cases of men differently wounded, and teaches that "it will redound more to your credit to save (a limb) on than to take it off. 'Tis true, indeed, that he is a good surgeon that can take off a limb dexterously, but he is a better that can save it on and heal it." To save life it is necessary "to stop the efflux of blood and to amputate the limb for if that it be left on it will Gangreen, and death will insue in a little time." It should be remembered, in view of this teaching, that the arteries were not tied either at the cut end or in their continuity, but that bleeding was stopped by the application of a tight ligature before amputation and by the use of buttons of tow or lint soaked in a styptic after the limb had been removed. Indeed Moyle expressly states that " The Ancients used to tie the greater vessels with double silk or thread when they had first taken hold of them with their Crowbill or other forceps thereby to stop the hemorage of blood; but this is not used now except upon extraordinary occasions. Others to restrain the bleeding used to sear the mouths of the great veins with a red hot cauterising iron but it is a dreadful operation to the patient and often brings great fears and horror upon him if not a fever.

" In the last Holland-wars we surgeons had a Royal Stiptic Water allowed us by his Majesty and it was sent down to us aboard the Navy, to each surgeon according to his complement of men, with directions how to use it. And indeed I found it very good in divers cases, as in wounds of the Head, and other dangerous hurts; for when I have applied it and it hath remained on two days and I have opened these wounds again, I have found perfect and laudable digestion, when—as I did not yet expect it. But in case of amputations it was not found so proper because the pledgets and compresses were to be wet in it and to be with the hand held fast to the end of the stump till the blood should stop; the which in heat of fight we cannot spare time to do but must be as speedy in our operations as possible."

In this delightful way the old surgeon discourses through more than three hundred pages, to the great benefit of the younger generation. The " Royal Stiptic Water " is of especial interest to those who are now advocating the treatment of wounds by synthetic urea, for one of its chief constituents was *urina juvenum*.

The Royal Stiptic Water seems to have been efficacious in the one case where Moyle used it. " In time of Fight at sea a man had his arm carried off by a bullet from the enemy. The bone was shattered all to pieces, and was so near the shoulder joint that there was no room for amputation with the saw to make a smooth end of the stump. There were some quassate loose ossicles at the end of the bone which I took out immediately with forceps; others there were but not so loose as to be now extracted. Some of the ends of the

nerves were hanging out as also some lacerated flesh and skin, which were now cut off as even as possible.

"But now the most important intention was *sanguinis sistendo* (for the blood flowed impetuously) from the *Axillaris vasibus*. Now I durst not apply the actual cautery, that part being so near the heart, for that the fire would soon cause that intolerable fervour to communicate the grief of this to all the principal parts and so bring on immediate Fever and Convulsions (if not present death). Nor dare I use any corrosive for that would be nearly as bad and the common astringents I feared would be too weak. I took buttons of *Stupa sicca* expressed out of the Royal Stiptic Water and armed them with the mixture, these I applied to the extremities of the bleeding vessels and a stupe of dry tow on the end of the bone, and then other stupes expressed out of the Royal Stiptic on these and over this made as good bolstering and bandage as the part would permit. Now together with these means there was good pressure with the hands, for without that (in these great Hemorhages) it will be hard to stop by the best restringents. The dressing was let abide 3 days and then was diligently removed, it looked fresh," and the man eventually recovered.

Moyle's second venture was published in 1708 under the title *Chirurgic Memoirs being an account of many Extraordinary Cures which occurred in the series of the Author's Practice, especially at Sea, when employed in the Governments service.* It is a record of cases many of which are interesting in themselves, but all made still more interesting by the language employed. Moyle was evidently a self-educated man, using the ordinary professional parlance of the time as it was employed amongst surgeons who made no pretence to learning. It is thus wholly different from the polished style of Wiseman, or the stately periods of the physicians who were Moyle's contemporaries. Moyle indeed felt his inferiority, for he says in his preface, "Let not my impilite stile disgust, if here or there you meet with an obsolete word or uncouth expression, 'tis my rural phrase or marine idiom, let your sublime generosity impute that to my less exornate dialect, let your eye be upon the matter of fact, which I can, without vanity, assert to be sound practical chyrurgery." A few extracts will show that, whilst he out-Rabelaises Rabelais in his extravagance of phrase, he was a shrewd and good surgeon.

"A Mariner aged about 34 years, hapned by a violent stroke with an Iron crow (in boarding of the enemy) to receive a considerable wound on the Mesocraneum, with a large fracture in the skull and a laesure of the Dura Meninx. The fracture was perfectly felt with the hand, through the wound. It was about two inches long and considerably wide. There was bleeding at the ears, eyes, nose and mouth with great astonishment and languor; sensible signs of a collision of the brain or a laesion of the Meninges. The man had a cordial given him but vomited it up again. He was had down to be dressed and venae section was immediately celebrated to prevent the blood's coagulating and induce its more free circulation which gave something of relief. His head was forthwith shaved with a capital razor when the hair had been first moistened towards the roots with oyl-Olive. Then decussate secation was made with an incision-knife sufficiently large and the Cutis pilosa, Membrana carnosa & Pericranium were seperated from the skull and the Mucronata of the Incisure (which had their center in the wound) were

clipp'd off with Probe-Scissors to make the better way for the operations which were to follow.

" There were two large segments of the bone beaten in, which lacerated the Crassior Tunicle. These were instantly extracted with forceps; then the fractured Chasma appeared vastly large and salebrous about the corona fracturae.

" The Sanguinis Missio in the Cutulus had by Revulsion obsisted (in some measure) the bleeding of the head; and now the grumous blood that was lodg'd in the capacity of the cranium, oppressing the meninges was absterged with a Linteolum and with Lint on the end of a probe and then the tunicle was wash'd. Then as well to focillate the brain as to obsorb any sanguinous humor that might remain extravasated a flannel stupe expressed out of warm Vin. rub. was applied . . . and over this was a dossell of dry lint applied in the chasma and pledgets of the same over the denude bone to the end that no Gleet from the Labia vulneris should insinuate into the Chasma nor yet contaminate the skull; as also to defend from the piercing air that would soon alter the bone from its colour natural to a labascous hue." The patient eventually made a good recovery.

The account of another cerebral injury runs as follows :—

" A young sailor running hastily in at the steerage-door and hitting his head violently against a cross beam, was struck down backward and receiv'd a severe bruise on the sinciput near the coronal suture but no wound nor yet sensible signs of a fracture. Howbeit, by the greatness of the blow and astonishment of the man it was reasonable to suspect all was not well within. I let him blood immediately for that is not to be neglected in all grand contusions whether external or internal. Next his hair was moistened with oyl on the epidermis and his head forthwith shaved. Then were the head, temples, frons and neck embrocated with the mixture of Vitell. Ovi, acet. vini & ol. Rosar and the Cataplasma of Hypocrates applied. The former to restrain the afflux of blood to the part and mitigate the pain; and the latter to discuss the tumour and contusion by drying up the extravasated blood and cerum already flowed to the part. The next day I dressed it after the same manner. The third day I found the contusion much deturged and the afflux appeased, so it seem'd as if it would soon be well.

" But two or three days after the man complain'd of an exceeding great pain in his head, this pain increasing so that he had no rest Day or Night. Then he had venae section again and Enemas exhibited but all availed not. His pain grew intolerable, especially under the place where the blow was received, insomuch that I suspected there was a fissure of the cranium and prevailed with the man to let me make incision and see; to which the man consented. So I made decussate incision and turned up the angles and razed off the Pericrane and gave it a restringent dressing at this time and put on it a compress and bound it up.

" Next day I tried to find a fissure, if there was any, but could see none, nor did the man's dolor assuage at all but still augmented. Then I concluded it was a concussio cerebri and that extravasated blood lay oppressing the Brain. I told the man so and that there was no way to save his life but by giving vent to it by Terebration. He answered that he had better suffer that

than live in such misery. Whereupon I made the operation with a Trepan and when the round piece of bone was taken out there gushed out abundance of putrid and filthy sanies by which discharge of matter the man found ease. Then I applied stupes expressed out of hot wine to the part, as I did each dressing after; the upper tunicle was ulcerated with the corrupt sanies and it smelt strong and offensive." And again the patient recovered.

In this practical manner Moyle treated his cases. Many of the records are interesting on account of the side-lights. Thus "Two of the gun-room crew falling out, the one hapned to receive an unlucky blow on the head with an handspike; insomuch as there was great contusion and laniation by the claw of the handspike which also bruised the skull and made a small fracture or fissure through the first table; it was on the upper part of the frontal bone." "Two men differing in heaving of ballest the one gave the other a violent blow with his shovel on the side of the head." "A man was wounded by a Pike under the left clavicle the point thereof hitting against the inner part of the scapula. He bled much at the wound but more inwardly hauked up much blood was very faint and breathed with difficulty," and was cured after the wound had been drained by "a hollow Turunda" made of a quill. This must be a very early instance of the deliberate employment of wound drainage by tubes.

One of the most interesting of the cases is a detailed account of an ovarian cyst. It occurred in "a gentlewoman aged about 32 years a married woman and mother of children in the year 1704. She was affected with a strange kind of dropsy and no body could discover what hydrops it really was. The venter only was tumefied as it had been an Ascites but being pulsed on did not fremit as such, nor being touched did it sound as a Timpany nor did the legs turge at all so that Physicians who saw it, knew not what to make of it. Midwives thought it was a Mole and Surgeons judged it a carneous substance but could not imagine from what part it generated; in short, all were at a loss about it. This gentlewoman had a windy rupture from her youth and it was still a grief to her at certain times and some thought this tumification might arise from that.

"Whilst the tumidity increased there hapened an Apostem to arise in the Inguen which suppurated and broke; then both herself and relations suspected her husband had given her the foul disease and a surgeon fluxed her for it but without success for she grew worse and worse. She had the advice of many physicians and took many things of their prescriptions; as likewise of a woman that followed her with powders and bottles of Drink but all to no purpose, she still swelled more and more and at last to a prodigious magnitude. It was three years from the beginning of it to this time that I saw it. . . . The Gentlewoman was sensible she should dye of it in a little time and therefore willed that after she should be dead she might be opened that it might be seen what the distemper was she dyed on. And in about four days after she dyed, and accordingly was opened; myself was not concerned, but being a near neighbour had inspection all along from the time I first saw her. She asked me if I thought I could do her any good but I ingenuously confessed I knew not her distemper and was not willing to tamper with what I did not understand. But opened she was. The cutis and muscles of the

abdomen and peritoneum being intersected all seemed right and so did the omentum too. But now in the place where the bowels should be there lay a wonderful immense Cystis (or rather Sacchus) full of water. Now this as it filled and increased in greatness pressed the viscera out of their place close up to the back and sides and had thrust up the liver and Ventricle with the Diaphragma before them upwards into the sinus where the heart and lungs should be. And the Lungs were pushed under the armpits and the heart turned up towards the throat and by the pressure was become flattish and the Matrix was depressed down into the pelvis, this vast saccus possessing all the space where these viscera should have naturally abode.

" In the next place this Cystis was opened and a vessel containing ten gallons was filled brink full with Limpha that was therein (and some to spare, which was received into another vessel). The thickness of this membrane or saccus was about that of a half-crown, strong and tenacious so that the peritonæum should sooner give way than that should burst. It had the advantage also of the unctious Omentum stretching out upon it. Now inside this saccus and springing from it were innumerable smaller cystises full of the same Lympha and a multitude of larger and smaller glands appeared in this membrane and adhering unto it."

The commentary upon the case runs : " Now I have observed this miserable disease unto you thus far. I will refer to Learned Physicians to find out means to remedy it ; for my part I as yet know of none. Some proposed tapping. But there was another woman at the same time had the same distemper and was tap'd for it. But when part of the water was discharged and the rest designed to be extracted by degrees, that which remained became corrupted and there came forth such a noysome stench that the Surgeons could not endure it and the woman dyed speedily, this discouraged the tapping of another. And indeed it cannot otherwise be imagined for as the water decreaseth the Cystis falleth from the orifice of the Tap in the Peritonæum and sheds its Lympha into the cavity of the Abdomen, so there will of necessity be putrification of the Lympha and Mortification of the Cystis. This highly deserves the maturest consideration of Physitians. There are doubtless new means revelled as well as new diseases manifested in every Age."

These extracts show how wide a gulf separated John Moyle from Richard Wiseman. Both surgeons had similar opportunities. Moyle remained a rough uncultivated practitioner, successful in his treatment because he did as he had been taught, and he desired to hand on his methods unchanged to the younger generation. Wiseman, a gentleman of exquisite sensibility, able for the first time in English surgery to generalize on the facts which he had observed and thus to lay the foundation for a scientific study of wounds and injuries.

GUNSHOT FRACTURES OF THE FEMUR.

AN ANALYSIS OF SIXTY CONSECUTIVE CASES, WITH A CRITICAL REVIEW OF THE GENERAL PRINCIPLES OF TREATMENT.

By E. W. HEY GROVES, Bristol.

A year ago I described in this Journal the principles which, in my opinion, should guide our practice in the treatment of gunshot fractures. In the present communication I propose to give a short history of a number of cases which were under my care in the summer of 1915, and to attempt to examine critically the various methods which have been advocated for this most difficult class of case.

Unfortunately, I am unable to review a large number of cases treated by different methods, which I have only seen for a short time, whilst on the other hand I have followed my own for weeks or months.

Another limitation to this article arises from the fact that I am away from books, papers, and libraries, so that the remarks made about methods other than my own are based chiefly upon a practical observation of these procedures as I have seen them carried out in various centres of the war, in England, France, Egypt, and on board a great number of hospital ships.

THE ESSENTIAL PRINCIPLES OF TREATMENT.

These may be briefly summarized as follows :—

1. *Immobilization of the limb.*
2. *Dressing without movement.*
3. *Extension of the broken bone,* sufficient to secure correct alinement and full length.
4. *Thorough cleansing and draining of infected wounds,* with provision for free or continuous irrigation.
5. *Semiflexion of the joints* above and below the broken bone, to relieve the tension of the great flexors and to place the limb in a position of physiological rest.
6. *Freedom of the uninjured parts of the limb and joints,* to ensure that massage and movements may be carried out from the earliest possible moment.

1. **Immobilization.**—The injured portion of the limb must be kept at rest. This requires no argument. It would never have occurred to any surgeon to violate the principle, had it not been for the practical difficulties of carrying it out without hindering the treatment of the wound.

The view has been taken that the infected wound is the all-important feature, and must be left open for access without any interference by a splint. The leg is accordingly laid between sand pillows, and lifted up each time for

dressing. When the patient is to be moved from train or ship to an ambulance, a splint is tied to the body and leg as a temporary measure. But not only does this plan entail great pain to the patient, and very hard work for both surgeons and nurses: it is wrong in principle. Every time the limb is moved and the comminuted bone fragments are made to impinge against one another, or against the soft parts, an auto-inoculation of the tissues occurs, which, together with the pain, will indefinitely prolong healing. I have repeatedly seen cases treated thus with a hectic temperature, while immediate improvement followed when the limb was placed on a cradle splint which allowed the dressing to be continued without movement of the leg.

2. **Dressing without Mobilization.**—This is really the cardinal point in the treatment of gunshot fractures. It is much more important in the leg than in the arm, because the weight of the lower limb causes great displacement to occur when the limb is freed from its supporting splint and the part is raised for dressing. In proportion as this principle is well carried out the dressing of the wound will be thoroughly done, because then not only dressing but drainage and irrigation are made easy. A leg which is allowed to lie on the bed can never drain so well as one which is suspended above it.

3. **Extension.**—Whereas in closed and simple fractures there are several alternative methods of securing proper reposition and fixation of the fragments during healing, in gunshot injuries there is only one, and that is adequate extension carried out in a correct line during the whole process of union. Simple splinting by wood, metal, or plaster-of-Paris is barred, because of the interference of these things with the dressing of the wound, or their becoming soiled by wound discharges. Open operation is out of the question, because of sepsis and the complexity of the fracture. The extension serves a double purpose; first as a method of immobilization, and second as the means by which the numerous fragments of the bone are drawn into correct alinement, so as ultimately to secure the full length and proper form of the bone. The first object of extension, namely immobilization, can be quite well secured in the case of the femur by merely tying the leg to the end of some frame splint or by properly arranging the bent knee over a double inclined plane. But the second, that of overcoming muscle resistance in order to secure the full length of the thigh, can only be obtained by the provision of a constant pull by spring or weight, firmly fastened to the leg so that it can act for six or eight weeks, or even longer. It is perhaps not sufficiently recognized that the treatment of a gunshot fracture of the femur is often a much longer process than in the case of a closed simple break. It is useless to extend the thigh unless the extension can be kept up for an indefinite period when necessary.

4. **Thorough Wound Treatment.**—In treating the wound associated with a broken femur, it is easy to do too little or too much. Large, dirty shell wounds require to be opened up fully, and thoroughly cleansed and drained. No drainage is satisfactory which does not leave a naturally gaping wound. That is to say, a really dirty deep wound can never be drained well by either tube or gauze. It must be so opened up by a judicious transverse division of the muscles that all its recesses become accessible to daily dressing and irrigation. On the other hand, clean perforating wounds made by rifle bullets seldom require any active treatment beyond a protective dressing.

Intermediate between these two types of wound are many torn wounds of a penetrative character, associated with the lodgement of a foreign body. About this class of wounds it is impossible to generalize. If the case is seen early, say within twenty-four hours of infliction, it is safer to open it up and clean it; but when it is seen at a later period, namely about the seventh day, more conservative treatment is probably safer, if there is no evidence of local inflammation around the wound, or of constitutional infection.

The danger of doing too much in the treatment of infected wounds associated with gunshot fractures consists in the unwarranted removal of pieces of bone. Fragments should never be removed from a fracture unless they are certainly dead or non-viable; often in the early stages this can only be ascertained by pulling the bit of bone out to demonstrate the absence of vascular supply. As a matter of fact, however much the bone has been comminuted, its constituent fragments are very seldom without vascular connections. This is easily demonstrated by dissection of limbs which have been amputated at an early period for gangrene. If a bit of bone is clearly lying loose in the tissues it is better removed from an infected wound; I do not believe there is any justification for the retention, still less for the replacement, of such a fragment in its septic bed. But this is a very different thing from exploring the wounds with fingers and forceps, and pulling out all the bone which can easily be removed. Such a practice leads to a flail-like limb which nothing can restore to usefulness except a difficult operation of late grafting. The general rule should be never to remove bone from a septic fracture until a late period, and then only when it is clearly dead.

5. **Semiflexion of the Joints.**—When the leg is kept straight on the bed in cases of fractured femur, the flexor muscles of the hip tilt up the upper fragment, the tense hamstrings cause the maximum of overlapping of the fragments, and, if the lower end is broken, the gastrocnemius tilts this backwards. These are text-book truisms, and yet there is no rule in the treatment of fractured femurs more commonly broken than that of keeping the thigh flexed and abducted and the knee bent. Quite apart from the question of accessibility for dressing, every broken leg should be slung off the bed, with the knee bent at about 120°.

This position of both hip and knee is midway between extension and flexion, and is that of 'physiological rest', in which the tension of the flexor and extensor muscles of each joint is most evenly balanced. A femur which in a straight position will require 25 lb. extension for its restoration to full length, can be adequately treated by 15 lb. when the knee and hip are flexed.

6. **Movement of the Muscles and the Joints.**—This may appear of very secondary importance, and it has sometimes to be subordinated to the other principles. But nevertheless, for quick return to functional use, and for the avoidance of pain, stiffness, and weakness, it ought not to be overlooked. When a fractured femur has been kept with a straight knee for six weeks or three months, the patient will generally take as long to recover a mobile knee as he did to acquire a firm femur. Whereas if, after the danger of wound infection has ceased, and the leg is in good position in its sling, daily massage with movements of the knee and ankle, and later of the hip, are carried out,

then by the time the bone is firmly united the patient is able to walk, and very quickly acquires the proper use of all his joints.

PRACTICAL DETAILS OF SPLINT CONSTRUCTION.

In all matters of military surgery it is necessary to take into account, not only the main principles of treatment, but also those practical details relating to transport and organization which are essential for the success of any method.

In the provision of a splint, for example, it is not enough to design an apparatus which will give good results in a modern hospital when used by its inventor. It must be so simple that its method of application will be self-evident; it must be made of materials which can be obtained easily, at small cost; it must be adaptable to any adult limb without special measurement; it must be readily sterilized, and easily packed, so that a number of splints can be provided for each hospital unit or ship without undue bulk. All these practical details have enforced themselves upon my attention lately, because I have been entrusted with the organization of a splint factory for the provision of special fracture appliances for some of the units of the Mediterranean Expeditionary Force.

At first, when we began our work in this place, the broken thighs were put up in wire cradle sling splints, the lower ends of which were attached to wooden uprights at the foot of the bed, this being in fact the same principle as that of the 'Balkan splint.' But it soon became evident that these could not be used on ships, neither could they be transferred to a stretcher for transport or for a visit to the *x*-ray department. And, further, in a tropical country any wooden structure attached to a bed for a length of time inevitably becomes bug-infected. We then substituted a wire frame on a T-shaped board which not being fixed to the bed, permitted the patient to be moved to a stretcher without alteration of the extension.

Another point required modification. In the original type of wire cradle splint which I described in 1914, the leg as a whole was elevated to an angle of about 30°, and this applies also to the 'Balkan splint.' Now if a leg is placed in this elevated position, active extension is essential during the whole time the method is being used, otherwise the force of gravity acting on the broken limb tends to shorten it, and increases the overlapping of the fragments instead of decreasing the deformity. This would make such an appliance useless when broken legs have to be put up quickly on ships or for transport.

The difficulty was overcome by making the wire cradle in the shape of a double inclined plane, so that the foot lay lower than the knee, though the whole limb was elevated from the bed. In this way the sling under the calf supports the thigh and acts as an extending force upon the femur. Such a splint merely requires the broken limb to be laid upon it, traction being exercised upon the thigh during the manœuvre; the patient will then at once attain efficient immobilization, which will not be disturbed by the dressings. But another practical difficulty presented itself. The wire cradle splints upon their wooden bases were very bulky and unwieldy for packing, and eighteen of them would about fill the body of a motor ambulance. We then made the T-shaped wooden bases detachable from the wire cradle, and made the cross-piece of the T swivel on the main board. But these wooden parts were still too bulky, and were further open to the objection that they absorbed any blood or pus which fell upon them. Therefore we now make the splint all of metal, the frame being of $\frac{1}{4}$-inch mild steel wire and the base of $\frac{3}{4}$-inch flat steel, with a swivelled crosspiece to prevent rocking. This pattern can be packed in nests of ten together, so that an ambulance can take out several hundreds at a time without difficulty.

THE TECHNIQUE ADOPTED IN THE PRESENT SERIES OF CASES FOR CARRYING OUT THE ABOVE PRINCIPLES.

The Wire Cradle Splint.—This in its latest pattern is shown in the accompanying illustrations (*Figs.* 210, 211, 212, 213). It is made in two

shapes, one (*Fig.* 212) having a longer thigh section than the other, for fractures of the upper third of the femur. Otherwise the one pattern serves for all fractures of the leg above or below the knee.

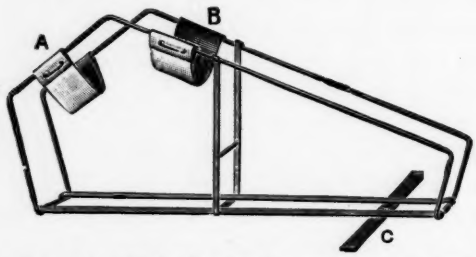


FIG. 210.—WIRE CRADLE SPLINT, SHORT PATTERN. (*a*) Sling above the knee; (*b*) Sling below the knee; (*c*) Cross-piece to steady the splint and take a bearing on the poles of a stretcher.

The splint is prepared for use by slinging double strips of flannel or rubber bandage across from side to side. The rubber bandage is employed at any spot adjacent to a profusely discharging wound, or when much irrigation is to be used. Ordinary rubber bandage fastened by a safety pin will answer the purpose; but lately I have used old inner tubes of motor tyres, which require to be fastened with a special wire clip. This stout rubber is not only much more serviceable, but it affords a really good elastic extension force when used under the upper part of the calf for fractured femurs, or under the lower end of the thigh as a counter-extension for fractured tibias. When the splint has been prepared by the bandage or rubber slings, the leg is lifted off the bed, using traction on the thigh, and laid upon the cradle, the knee being bent over the angle of the splint as a final act in its emplacement. If the patient is delirious, or if he has to be moved to the operating room or *x*-ray department, a bandage is placed round the lower part of the leg above the ankle. (If the fracture is below the knee, the foot is bandaged to the foot-piece before placing the limb on the splint. The foot-piece, having two outstanding metal bars, serves to prevent the foot from rolling laterally, while not interfering with extension.)

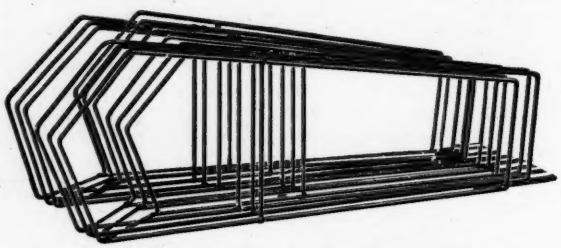


FIG. 211.—WIRE CRADLE SPLINT, SHORT PATTERN. Six packed together.

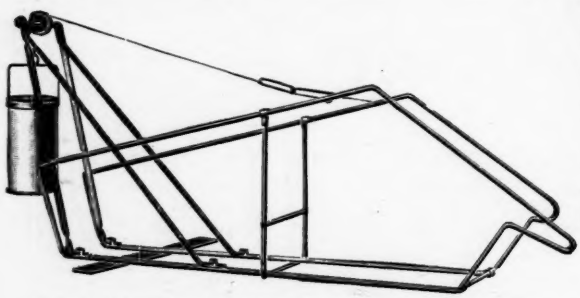


FIG. 212.—WIRE CRADLE SPLINT, LONG PATTERN. Arranged for extension.

This much of the treatment is to be carried out at the earliest possible moment after the case has been seen. Apart from attention to the wound, nothing more is required in the early stages, whether on board ship or in hospital, except possibly the provision of counter-extension.

The limb, once placed on the splint, is never removed from it, unless after full surgical anæsthesia given for the purpose of an operation.

Preliminary Extension Methods.—There are three different means by which extension can be carried out without having recourse to transfixion; and whether the latter is to be done later or not, these simpler methods are of great value in the early stages when the condition of the patient or his environment make anything of the nature of an operation undesirable.

In the first place, the mere bending of the knee over the double inclined plane of the cradle splint serves to maintain the traction force with which the limb has been lifted. This may be made still more efficient by making the first sling below the knee of well-padded tyre-rubber. The leg below the knee

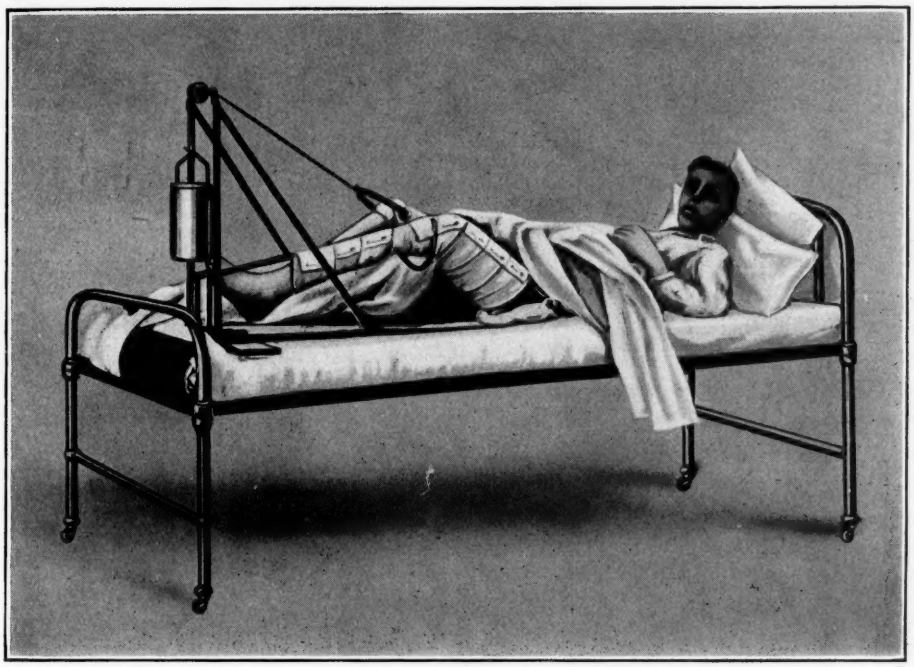


FIG. 213.—WIRE CRADLE SPLINT IN USE. Transfixion extension. The middle thigh-slings are taken out preparatory to dressing the wound.

then acts as a lever which pulls upon the thigh. In the second place, weight extension can be applied in a few minutes by means of the metal leg cradle placed under the calf (*Fig.* 213). This has two outstanding eyes which serve for an attachment of the extension cord. It is fastened to the upper part of the calf of the leg by a few turns of bandage. Thirdly, the usual adhesive plaster can be applied either to the lower third of the thigh—leaving the knee flexed, or to the whole leg below the injury, pulling on the leg in an almost extended position. I have now given up the use of adhesive plaster for preliminary extension, because the other methods serve quite as well in the primary stages, they take less time to apply, and they are not subject to the great drawback of fixing the knee in almost full extension.

On Counter-extension and Abduction.—No extension of the femur is satisfactory unless provision is made for adequate counter-extension. In the early stages, when immobilization for transport and the urgency of the wound infection are the dominating factors, it may be postponed; but even at first it is much better to provide it.

To some extent the mere holding up of the leg provides counter-extension by the weight of the body, and this may be increased by tilting the foot of the bed. But this is not enough when prolonged and exact extension is required; for the patient will, every time he is lifted on to the bed-pan, unconsciously slip down in the bed.

In all fractures above the middle of the thigh, the position of abduction has to be maintained, or in other words, adduction of the lower fragment prevented. Adequate counter-extension and abduction can both be secured by the same means, viz., a padded bandage round the sound thigh, attached to the head of the bed. This may seem a small point, but as it is one of the essential points of difference between the method I am advocating and others in common use, it deserves careful consideration.

Counter-extension must be obtained by a hold on the pelvis, that part of the skeleton just above the fractured bone. This hold may be taken on the side of the fractured limb or on the opposite. There are two great advantages in the latter arrangement which appear to me decisive. In the first place, a band round the thigh of the unwounded side will not be liable to be soiled by wound discharges, fæces, and by lotions, and will interfere less with the dressing of any wound high up in the leg. And secondly, when applied to the sound leg the counter-extension force will tilt the pelvis, and thus secure abduction automatically. In civil practice, with comparatively large beds and plenty of ward space, abduction may be obtained by bringing the broken leg out to, or over, the side of the bed; but this is impossible in military work when using hospital ship cots, and therefore a method which secures abduction of the limb by tilting up the pelvis on the sound side, leaving the leg side by side with its fellow, is of great advantage.

Extension during the Repair of the Fracture.—As soon as the wound infection has been adequately treated and *x*-ray pictures taken, efficient extension must be applied which can be maintained for six or eight weeks. This is best done by transfixing the lower end of the femur or the head of the tibia, and attaching a weight varying from 10 to 30 lb. In the majority of cases the transfixion is done within three days of admission to hospital. It is postponed in cases where the wound infection is of so grave a character as to overshadow the fracture in importance. The postponement is for two reasons. First, in cases of severe infection it is undesirable to add to either the trauma or the wounds, even in small degree, and there is no object in doing so, as the means for temporary extension above described are quite adequate. Next, the transfixion can only remain operative for six or eight weeks, as the pin must then be removed. When the fracture is severely infected no bone repair occurs, and therefore there is no special object in an exact restitution of bone form, and further, the period when final union will occur may be prolonged to several months. Therefore it is better to postpone transfixion until the wound is healthy, so that the six or eight weeks of extension shall correspond

with the period when bone repair is taking place. The lower end of the femur is the site of election for transfixion; but it is better to choose the head of the tibia if the fracture is very low, or if any wound or extravasation of blood exists near the condyles. I confess to having had a strong prejudice against transfixing the head of the tibia for fracture of the femur, because of the pull then being through the ligaments of the knee, and the hindrance which this site imposes upon the movements of the joint. But the objection has not so much weight in practice as in theory; and whilst I have never had occasion to regret transfixion of the tibia, there have been cases in which I have transfixed the femur and subsequently regretted not having used the tibial site.

The Technique of Transfixion.—This is done under gas anæsthesia whilst the patient is in bed with his leg supported on the cradle splint. The transfixing-pins are made of plated steel, and are $6\frac{1}{2}$ in. long and $\frac{5}{16}$ in. thick. One end is chisel-pointed, and the other slotted in order to fit a hand-brace. The region of the knee is shaved, and painted with iodine. An assistant stands on the outer side of the limb and steadies the leg, pulling the skin towards the fracture. The operator leans across the patient, and having fitted the pin to the brace, he introduces it through the skin by a sharp push until it is on the bone at the upper part of the prominence of the inner condyle. It is then drilled through the bone until the point of the instrument pushes the skin in front of it on the other side, when the integument is pierced by pressing it upon the point of the drill. The reason for working from within outwards is that the internal condyle is more sharply defined than the outer, and also that, as the limb lies somewhat on its outer side, it will be easier to drill downwards from the inner aspect than upwards from the outer. The avoidance of septic sores round the pin will depend upon the latter fitting snugly into the holes in the integument without making an incision, and also upon the avoidance of traction on the skin, this being achieved by pulling the skin upwards during transfixion. When the pin is in its place, about one inch projects from either side of the knee. These projecting ends are surrounded by a simple gauze dressing, and fitted to a horseshoe-shaped piece of metal to which the extension cord is tied. (See *Figs.* 213, 214.)

Weight Extension, its Amount and Duration.—The most convenient weight to use for extension is the graduated shot tin supplied by the Army Medical Stores. When full it weighs 16 lb., and this is amply sufficient for all recent cases. The extension cord runs over a pulley borne by two metal uprights which are bolted to the base of the cradle splint. The weight hangs between these two uprights, and if the patient has to be moved it is secured from swinging by a loose encirclement of rubber tubing which surrounds both weight and uprights.

I have never seen a recent case in which 16 lb. failed to restore the limb to its full length within two days, judged by both *x* rays and measurements. Usually, in fact, we find actual over-extension of about half or three-quarters of an inch—a good sign, showing that the ends of the bone are disengaged. The weight needs no reduction for several weeks, when it is reduced by one-third. In the case of old fractures of several weeks' standing, when mal-union has begun, a larger weight is required, 20, 25, or 30 lb., according to the lateness of the treatment and muscular development of the limb. In most cases

the weight extension must be kept up for six weeks, though this period can often be shortened, and in exceptional cases lengthened to eight. In general terms, it is retained until firm union has taken place, as tested by absence of sensation by the patient when the weight is temporarily released. This cannot be definitely predicted at any given period, but it occurs early in proportion to the absence of infection, the proximity of the fracture to the lower end of the bone, and the obliquity of the fracture. The cases in which prolonged extension is most necessary—even after union has occurred—are fractures through the trochanter and upper third, because in such cases there is a strong tendency for the unbalanced adductors to angulate the bone at the site of fracture.

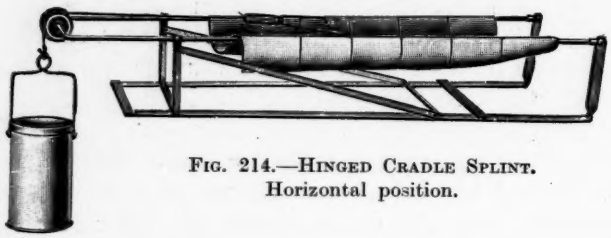


FIG. 214.—HINGED CRADLE SPLINT.
Horizontal position.

Extension for Prolonged Periods.—It not infrequently happens that after six or eight weeks of extension, either the fracture is ununited, or the union is weak and apt to undergo secondary deformity. This applies particularly to cases with prolonged suppuration, or to those in which there has been bone loss which has to be made good by callus. It is inadvisable to prolong transfixion beyond the period named. It is observed that the pin becomes loose and the skin-holes sore, and this should be the signal for removal. But if full extension has been kept up all this time, a comparatively slight force will serve to maintain it, and this may be applied either by adhesive plaster or by the other methods mentioned under the heading of preliminary extension. In very exceptional cases the tibia may be transfixed for another period after the pin has been removed from the femur.

The Tracking of Suppuration up the Thigh.—The objection has been raised against the elevated position of the thigh in septic fractures, that it tends to make the suppuration track up towards the hip; and there is some force in the criticism. But when this occurs, it is generally evidence that the original wound was insufficiently opened and drained in the first place, and I think that it may be prevented by some alertness in this respect, and particularly by securing free posterior drainage by transverse incisions.

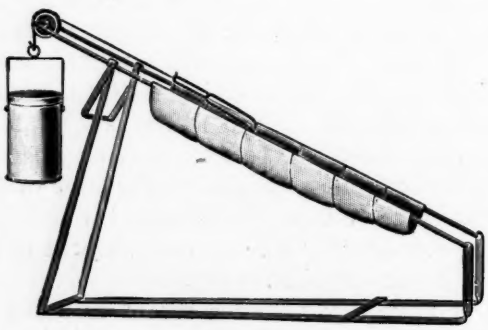


FIG. 215.—HINGED CRADLE SPLINT.
Raised on the strut, as for dressing.

Another means which is of great value in preventing this complication is the use of a Bier's bandage above the wound. This tends to close the

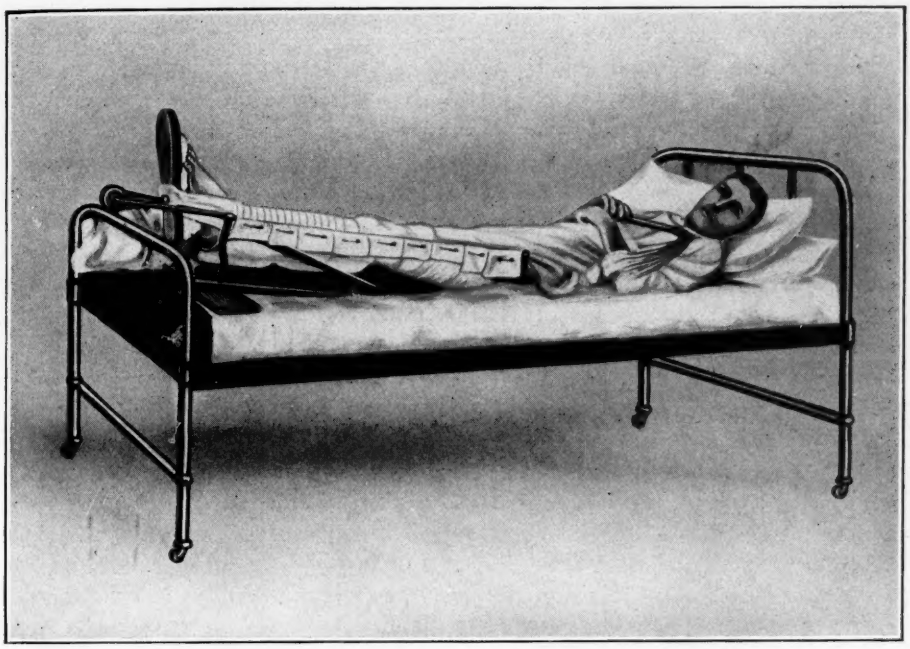


FIG. 216.—HINGED CRADLE SPLINT IN USE. Horizontal position.

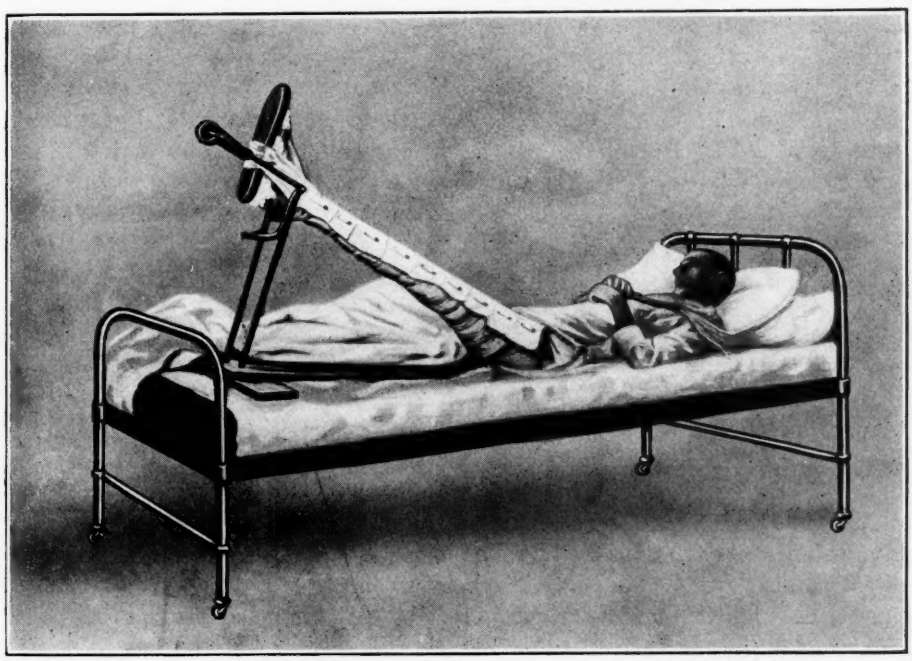


FIG. 217.—HINGED CRADLE SPLINT IN USE. Raised on the strut, for dressing the patient.

connective-tissue spaces in the upper part of the thigh, and to direct the discharge of pus out through the wound.

Nevertheless, in some cases an upward pocketing will occur; and if this is not prevented by enlarging the existing wound, the elevated position must be abandoned, and a special straight cradle splint used, such as is here figured (*Figs.* 214, 216, 217). It is practically a Thomas knee-splint without the ring, arranged on a hinge opposite the hip-joint, and provided with a pulley-wheel at its lower end. By this means the leg is kept extended with the knee straight. When the dressing has to be done, the leg is raised from the bed, and a metal strut supports the lower end of the splint as long as may be necessary, without relaxation of the weight extension. In a series of sixty cases I have only had occasion to use this three times, but in these patients the device was extremely useful.

Massage and Movements.—When the leg is lying in the cradle splint, with the weight extension attached, the whole of the front surface lies free from bandages except in the immediate position of the wound. All the joints are free. After the first week massage is begun, with gentle passive movements of the ankle and knee. When early union has occurred, generally after three weeks of transfixion, active movements of the knee are practicable, and then passive movements of the hip. In this way, by the time that full union has occurred, the muscles have a good tone and the joints are quite supple, so that when the patient begins to walk his convalescence will be rapid.

Modifications of Transfixion Methods.—In a few cases of fractured femur I have used certain modifications of the simple transfixion method. The horseshoe screw clamp (*Fig.* 218) is a device in which two pointed screws, held by a metal horseshoe, are driven into the outer and inner aspects of the condyles for about a quarter of an inch, not penetrating the entire thickness of the bone. Its advantages are, that it can be easily applied under local anæsthesia, it only makes a superficial wound of the bone, and in cases of a vertical split between the condyles it clamps the latter together. This last is the only indication for which I now employ it, and it is then very efficient. The idea that it avoids the danger of septic infection involved by transfixion is only partly true, because, though the interior of the bone is not opened, there still remain the skin wounds by which sepsis may gain access to the connective tissue of the thigh.

FIG. 218. — AUTHOR'S HORSESHOE SCREW CLAMP FOR GRASPING A BONE WITHOUT TRANSFIXION.

The double transfixion apparatus which I described last year has also a very limited scope. It is by far the most powerful and accurate method I know for immediate or speedy restitution to full length of a broken femur with much overlapping: for this reason it is of great value as the first stage of an operation for operative fixation of an old fracture. But its use is attended with much more pain than single transfixion with weight extension, for the obvious reason that what is done by the screws of the double transfixion

apparatus in a few minutes is only accomplished slowly by the weight acting for several days. Another objection is that the upper transfixing-pin produces soreness and ulceration much sooner than the lower, because it has to traverse so much more of soft tissues. It therefore cannot be left in place for more than four weeks, and by this time union will not have occurred.

A SERIES OF SIXTY CONSECUTIVE CASES OF GUNSHOT FRACTURE OF THE FEMUR.

In presenting this list of cases, all of which were under my care last summer, I have tried by means of a tabulated form, *x*-ray pictures, and drawings, to display the salient facts in the most concise and least wearisome manner. Before speaking of results, it is necessary to notice both the time at which the cases were received and the period over which observation extended.

Periods at which the above Treatment was Begun.—In the great majority I was responsible for treatment directly the cases were disembarked from the hospital ships. The remainder were cases of special difficulty which I was asked to treat in other hospitals. Those treated by myself were :—

Within the	1st	week	of	injury	18
,, ,,	2nd	,,	,,		29
,, ,,	3rd	,,	,,		4
,, ,,	4th	,,	,,		2
From ,,	5th to	13th	,,		7

FIG. 219.—*Case* 9, after treatment. Comminuted oblique fracture, middle third of shaft. Transfixion extension 38 days. Shrapnel débris *in situ*. Good result.

Periods of Observation.—These are reckoned from the date of the wound until the patient left our care, and are as follows :—

Seen for	less than	1	week	3 (all fatal cases)
,,	,,	4	weeks	5
,,	,,	6	,,	15
,,	,,	8	,,	17
,,	,,	10	,,	9
,,	,,	12	,,	3
,,	more than	12	,,	8

It will be seen from these periods that as the majority of our cases (52) were seen for six weeks or more, we are in a position to state with some degree

of assurance what final result might be expected; but in each case the value of this expression of opinion will be in direct proportion to the length of the observation period.

Mortality.—There were six deaths, as follows:—

Case 47.—Secondary hæmorrhage; amputation; death on fifth day.

Case 52.—Secondary hæmorrhage; ligature of femoral artery; death on eighth day.

Case 51.—Sepsis, complicated by dysentery; death on seventeenth day.

Case 57.—Sepsis, also in knee-joint and tibia; death on thirty-ninth day.

Case 29.—Dysentery; death on sixty-third day.

Case 50.—Dysentery and sepsis; death on one hundred and tenth day.

FIG. 220.—*Case* 10, after treatment. Oblique comminuted fracture just above middle of shaft. Transfixion 31 days. The bullet perforated one thigh, breaking the femur, and lodged in the opposite. Good result.

Amputations.—In six cases the limb had to be sacrificed; in two even this did not save life.

Case 47.—For secondary hæmorrhage; death.

Case 57.—For sepsis in knee-joint and tibia; death.

Case 55.—For gangrene due to primary lesion of the popliteal artery and vein; recovery.

Case 59.—For sepsis of the knee-joint; recovery.

Case 34.—For sepsis of the knee-joint; recovery.

Case 46.—For necrosis and sepsis; recovery.

Taking the last two groups together, there were ten cases, or one in six, in which life or limb was lost. In four of these, primary sepsis was the cause of disaster, two by reason of secondary hæmorrhage. In three, the

result was unconnected with the fracture, one being from a primary injury of the popliteal vessels, and the other two from dysentery. In the remaining three, infection of the knee-joint was the determining factor, and the importance of this becomes even greater when it is noted that in no case was the limb saved where septic infection involved both the fracture and the knee-joint.

Results in regard to the Limbs Saved.—These may be summarized as follows:—

Union with deformity ..	2
Delayed union	8
Good union but unhealed wounds	3
Good in every respect ..	37

Union with Deformity.—Both these cases were severely infected. In one (*Case* 43) the deformity was caused by a secondary or late bending of the callus mass in a subtrochanteric fracture. In the other (*Case* 48) a lateral displacement of the fragments had persisted, though the alinement and union appeared to be good.

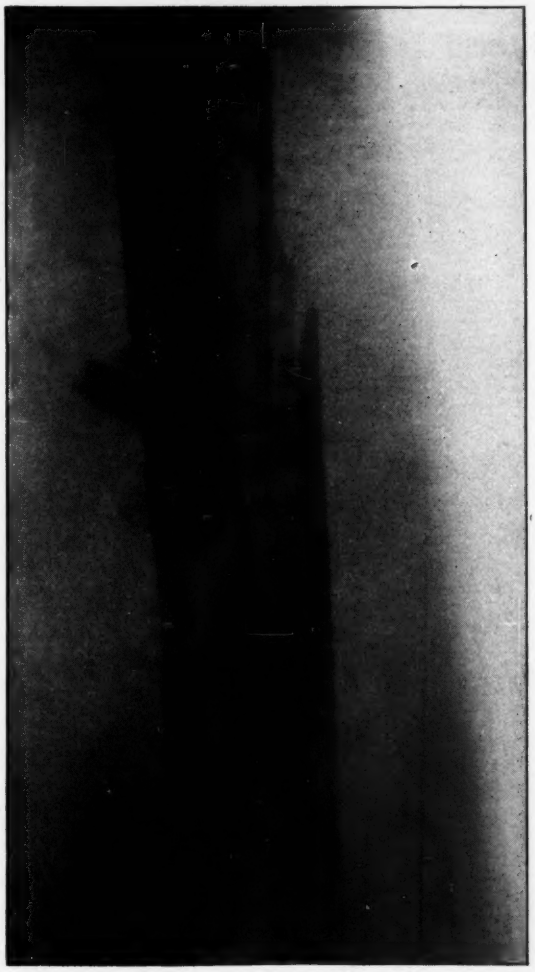


FIG. 221.—*Case* 12, after treatment. Comminuted fracture of middle of shaft. Transfixion 30 days. Good result.

Delayed Union.—These cases are of two kinds. In the first, which comprises four cases, the union was merely slow, but actually had taken place, or was taking place, when the patient was last seen. *Case* 8 was one treated by double transfixion, but three inches of shortening had occurred, and seventy-eight days elapsed before treatment. *Case* 19 was a clean but much comminuted fracture of the lower third of the femur, in which union had not occurred at the beginning of the sixth week, but appeared to have taken place at the end of the seventh when the patient left my care. In *Case* 38, union took place in the eleventh week, and in *Case* 33, in the fourteenth, both being cases of mild sepsis. I have no doubt all these four men will have good legs, as full length and perfect form have been restored to the femur.

The other four cases one cannot speak about with any assurance, as they were all complicated with much sepsis and much comminution. In one

(*Case* 44) much bone had been removed before I saw the patient. In the other three (*Cases* 54, 56, 58) it is probable that the slow process of exfoliation of dead bone must take place before final union occurs.

Late Healing of Soft Parts.—There were three cases in which the bone had united well, but in which at the time of parting with the patient the wounds were unhealed. In all of these (*Cases* 41, 42, 53) there had been formation of pockets of pus after the preliminary infection had subsided. These secondary abscesses had been opened, and their cavities still required drainage at periods of 55, 55, and 49 days respectively after the original wound.

FIG. 222.—*Case* 16, after treatment. Much comminution below middle. Good union after 26 days' extension.

Good Results.—By the term 'good,' in these cases of fractured femur, I mean that the bone is restored to its full length (often with half an inch to spare), firmly united, that its axis is in perfect alinement, and the muscles and joints are active and supple. Radiograms of many of the cases, with tracings of others, are reproduced in order to give some idea of the types of fracture before and after treatment. But inasmuch as the *x* rays do not show callus in its early stages, nor do they certainly distinguish between dead and living bone, this means of examination is only of limited value in deciding as to results.

The actual number of good results, according to the four tests of length, union, alinement, and supple joints, was thirty-seven, which I think a fair representation; for although it is possible that some of these may develop a late secondary displacement or a septic focus, yet on the other hand there are seven cases in the last two lists (delayed union and delayed healing), most of which will give good results ultimately. This represents 74 per cent of the cases in which the limb was saved.

The Relation of Sepsis to the Results.—In the following table the cases are divided according to the nature and degree of infection of the wound. It is at once obvious that the degree of sepsis is by far the most important factor in the determination of the result.

DESCRIPTION OF WOUND	NUMBER OF CASES	DEATH OR AMPUTATION	GOOD RESULT
No wound ..	2	1 (Dysentery)	29
Clean	30		
Slight sepsis ..	10	1	5
Severe sepsis ..	18	8	3

Of the thirty-two clean cases, only two were not satisfactory at the time of discharge. In one of these (*Case* 8) treatment was delayed for seventy-

eight days. In the other (*Case* 19) there was much comminution, and the union, which was delayed till the seventh week, would probably be ultimately satisfactory.

Of the ten cases with slight sepsis, two (*Cases* 33 and 38) were cases of delayed union merely, with satisfactory prospects of a good result finally, one (*Case* 34) lost his limb because of infection of the knee-joint, and in two (*Cases* 41 and 42) the bone union was good but sinuses remained unhealed.

Of the eighteen cases of severe sepsis, two healed with deformity, four presented non-union or delayed union (*Cases* 44, 54, 56, 58), and in one the wounds were unhealed on discharge (*Case* 53).

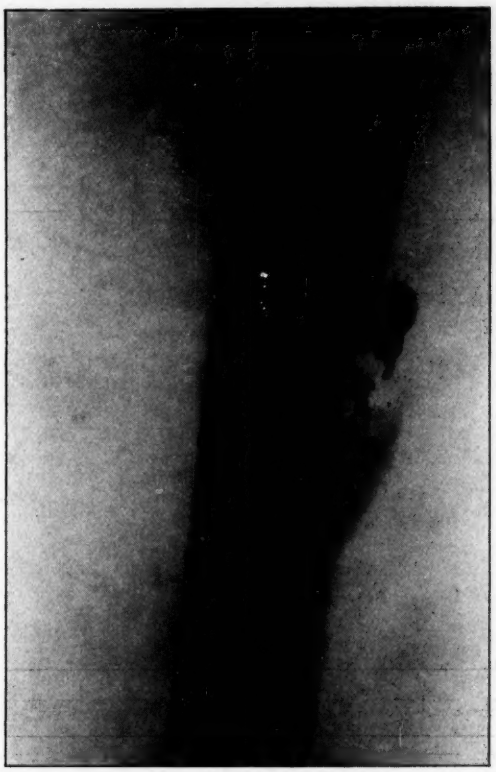


FIG. 223.—*Case* 17, after treatment. Oblique fracture of shaft with three inches of shortening. Shrapnel ball *in situ*. Transfixion 32 days. Good result.

FIG. 224.—*Case* 17. Diagram before treatment, showing angulation and three inches of shortening.

The Relation of Comminution to the Results.—It is a matter of no little difficulty to determine this question, because much comminution is so often associated with much sepsis. In general terms one may certainly assert that comminution in no way hinders or delays the attainment of good results (*Case* 19 seems to be the only exception to this rule). Indeed, if figures are of any value in so complex a problem, we may even go further, and say that comminution actually is an element of good prognosis. Thus, taking the first

three groups in the above table, where sepsis was slight or absent, there were sixteen cases with no comminution, and twelve good results—75 per cent; twenty cases with some comminution, and sixteen good results—80 per cent; six cases with much comminution, and five good results—83·3 per cent.

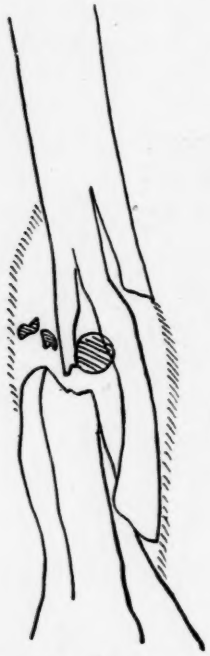


FIG. 225.—*Case* 19. Much comminution. Shrapnel ball *in situ*. Very slow union. Callus shown by shaded outline.

The Treatment of the Wounds.—The treatment of the original wound was much less in my own hands than the treatment of the fracture; for as the majority of the cases only reached us seven to fourteen days after receipt of the injury, we had nothing to do with primary treatment. In nineteen cases we undertook thorough wound treatment, opening up, cleaning, and draining; in eleven cases late abscesses had to be opened; in the rest simple dressing was all the treatment required.

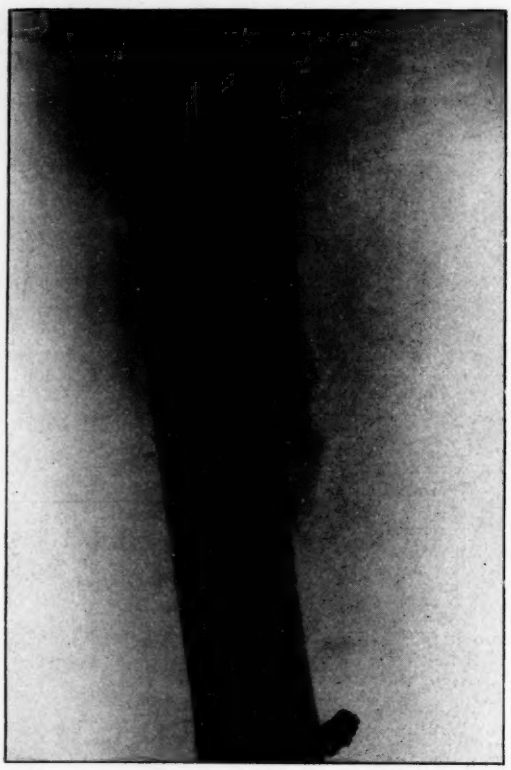


FIG. 226.—*Case* 22, after treatment. Oblique fracture of middle of shaft. Transfixion 24 days. Good result.

As regards foreign bodies, too, the treatment must depend much on the period at which the case is first seen. If seen for the first time, say, ten days after the receipt of the wound, and there is no evidence of local or constitutional infection, then the presence of a foreign body is no justification for opening up a wound which is healthy. Shell fragments (apart from mere débris) ought always to be removed at the earliest possible moment, but if they have been left, and are causing irritation, there is no necessity to cut them out at a period several weeks

later. In the above series we only removed foreign bodies six times, and in ten the bullet or shell fragment was left *in situ*, as the drawings reproduced show.

The Treatment of the Fracture.—In every case the treatment of the fracture was carried out on the lines laid down above, that is, the limb was

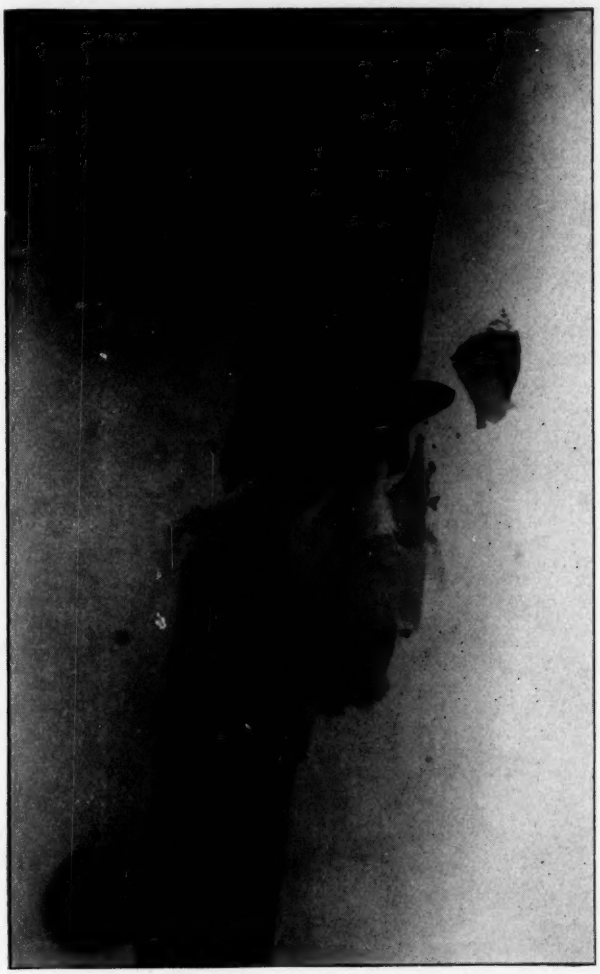


FIG. 227.—*Case* 25, after treatment. Comminuted subtrochanteric fracture. Bullet débris left *in situ*. Transfixion 28 days. After pin had been removed bone showed signs of bending. Therefore adhesive plaster extension was applied for 30 days. Good result.

slung up on a wire cradle splint so that the dressing could be done without interfering with the immobilization of the bone. As regards the details of extension, they were as follows :—

No Extension.—Three cases. Two of these were cases of severe sepsis,

in which death occurred within two days; the other showed no tendency to displacement of the oblique fracture.

Adhesive Plaster Extension only.—Three cases. Two of these were very serious, and died within a few days; the third was a case of severe sepsis in which thorough opening and draining of the wound caused rapid healing, and in which the bone quickly united in good position, so that transfixion was unnecessary (*Case* 60).

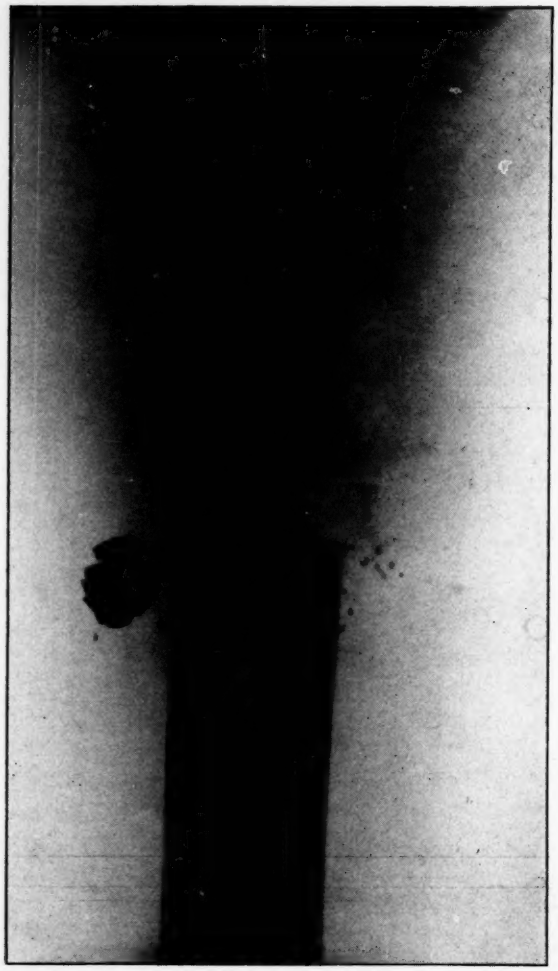


FIG. 228.—*Case* 30, after treatment. Comminuted fracture of shaft, with shrapnel ball *in situ*. Transfixion extension 27 days. Good union. Note evidence of over-extension.

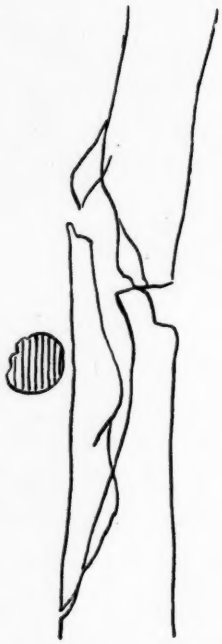


FIG. 229. — Diagram of *Case* 30, after 27 days' extension. Note over-extension. Firm union in 5th week.

Transfixion Extension.—Fifty-four cases.

35 cases—transfixion of the femur only.
12 „ transfixion of the femur, preceded or followed by adhesive plaster extension.
6 „ transfixion of the tibia. All these were injuries near the knee-joint.
1 case transfixion of the femur, followed by transfixion of the tibia.

The relative advantages of the different methods of attachment of weight extension require careful consideration.

ADHESIVE PLASTER EXTENSION.—This has been the only method used until recent years, and its features are well known. If properly applied it is certainly quite effectual, but it has peculiar drawbacks when used for septic gunshot fractures. The leg has to be kept with the knee almost fully extended, and this will tend to produce stiffness of the joint. Plaster applied only above the knee does not give a secure hold, because that part of the limb is conical, with the small end of the cone towards the direction of the pull, and the edge of the encircling plaster above the knee will tend to cut into the skin as it is pulled upon. In all the very septic cases the limb rapidly wastes, and this causes the plaster envelope to become loose and ill-fitting, when it slips from its place and needs to be re-applied. It is a painful process to take off the adhesive plaster from a broken leg, much more so than the removal of a transfixing-pin. The encasing of the whole of the unwounded part of the leg in plaster makes it impossible to carry out massage. The firm application of adhesive plaster to a thin leg in a septic case is very liable to cause injury to the skin and pressure sores. I have used plaster extension comparatively little in this series, and, omitting the two fatal cases, in only one (*Case* 60) was it the sole means of extension. In the others it was employed either before or after transfixion; in the former for cases of marked sepsis pending the recovery from infection; in the latter when there was evidence of, or reason to fear, a secondary bending of the soft callus after transfixion had been removed. But now that we have devised the metal cradle for the calf, I think this latter appliance will do away almost entirely with the adhesive plaster.

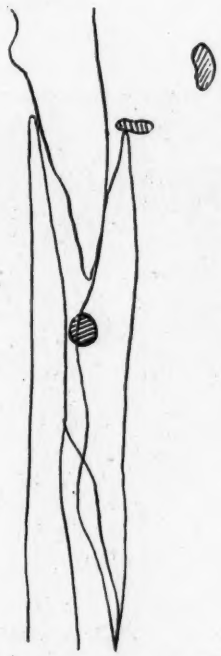


FIG. 230.—*Case* 37, after treatment. Remarkable long spiral fracture.

FIG. 231.—*Case* 39. Comminuted lower end of shaft, after extension. Some over-extension can be seen. Firm union after 26 days' extension.

TRANSFIXION OF THE FEMORAL CONDYLES.—This is the method of greatest efficiency from a mechanical point of view. That is to say, by its means and by the employment of a suitable weight (16 lb. in recent cases) the bone can be restored to full length within two or three days, and this restoration of form can be maintained for six to

eight weeks. I know of no other method of which this can be said. Contrary to common preconception, it is practically painless. Its application requires gas anæsthesia, and the first twenty-four hours of pulling upon the limb requires morphia, but the presence of the pin is quite unknown to the patient, and it causes much less discomfort than any other method of applying the same force.

FIG. 232.—*Case* 40 before extension. Comminuted fracture through trochanter.

FIG. 233.—*Case* 40, after 42 days' transfixion. Good result.

Against these advantages has to be set the fact that it involves two wounds which, after several weeks, are liable to become septic, and that these septic wounds in susceptible patients may lead to tracking of suppuration into the thigh or knee-joint. This may be considered in the three following aspects :—

1. *The Danger of Primary Infection.*—This, I think, can be completely

avoided by ordinary precautions, and amounts to nothing more than the risk incurred in a tenotomy or osteotomy.

2. *The Danger of a Late Infection of the Deep Parts of the Bone.*—I can only say that I have never seen any evidence of this, either of deep abscess or other bone trouble. At first the pin absolutely fills its own bed, and later, if

FIG. 234.—*Case* 41 after treatment. Comminution of middle of shaft. Septic wound. Much shell débris. Transfixion 39 days. Good union. Wound unhealed

absorption of bone occurs, the extra cavity is filled by granulation tissue, which also fills the whole track when the pin is removed.

The removal of this pin cannot carry septic matter into the bone if care is taken to clean its distal point and the cavity which surrounds it. If this presented any real grounds for apprehension, it could be entirely obviated by the use of the horseshoe screw clamp, which only bites into the outer shell of bone and does not penetrate its interior.

3. *The Danger of Sepsis spreading from the Area of Soft Tissues Perforated.*—This, to my mind, is the only real ground for concern. The danger is slight. In six of our cases the pinholes became converted into ulcers about half an inch in diameter, and three of these led up to pockets of pus in the thigh. We soon noticed, however, that this ulceration was much more marked at the point of entry than of exit of the pin, and it became evident that it depended on the fact that whilst a scalpel wound was made for the insertion of the pin, the exit was made by merely cutting down upon the pin point. In other words, if one can avoid an open wound, the ulceration does not occur. I now use a chisel-pointed pin, which is thrust into the condyle, cutting its own hole in the skin, and being pushed out on the other side. If, in addition to this precaution, the skin is pulled well up, so as not to be dragged upon by the extension, then this skin ulceration will, I believe, be entirely avoided.

FIG. 235.—*Case* 53, after extension. Severe infection, with a fissure running down into the knee-joint. Good union after 36 days' extension. Fortunately the joint did not become infected.

FIG. 236.—*Case* 54, after treatment. Extreme comminution of shaft. Severe sepsis. Transfixion extension (10 lb.) for 58 days, followed by plaster extension. Union incomplete.

But in two of the six cases with septic pin-holes there was also a suppuration of the knee-joint. In *Case* 34, though sepsis was at first slight in the original wound, it gained ground, causing abscesses which tracked the whole length of the thigh and down into the calf. The suppuration in the knee-joint was not evident until after the removal of the pin, and it may have had nothing to do with the transfixion; but, on the other hand, the pin wounds

FIG. 237.—*Case* 56, before treatment. Extreme comminution and severe sepsis.

FIG. 238.—*Case* 56, after 63 days' transfixion extension. Good shape, but union is incomplete.

were nearer to the joint than those of the gunshot injury, and may have been the cause of the joint infection. In *Case* 50 the patient had both severe sepsis and intractable dysentery. At the post-mortem the knee-joint was full of thick pus, without erosion of the cartilages, and this collection of pus was connected with the transfixion wounds by an irregular track. The fact that the cartilage was not affected shows that it was a mild or late infection, probably

due to the lowered resistance of the patient, who had been reduced to the condition of a skeleton after a hundred and ten days of sepsis and dysentery.

I am therefore reluctantly forced to the conclusion that transfixion does involve a certain risk of infection of the knee-joint, though I believe that the risk—being realized—may be avoided by making the transfixion without a knife wound, by postponing it until infection is overcome, or by using the tibia as the transfixion point. Transfixion of the tibia, as I have said, is a very useful alternative to that of the femur. Not only is the point of application out of the danger zone of the knee-joint, and away from wounds low down in the thigh; but if a point just on a level with the tubercle is taken, there are no soft parts involved besides the skin and the fascia, and ulceration round the pinholes does not occur. If extension is applied before permanent contraction has taken place, not more than 16 lb. weight is required, and this does not do any damage to the ligaments of the knee when traction is made on the tibia.

FIG. 239.—*Case* 59. Fracture of the lower end, with two shrapnel bullets *in situ*. The knee-joint was infected by the lower wound, and the leg had to be amputated.

FIG. 240.—*Case* 60, after 4 weeks' extension. There was a severe gas infection of the thigh, which rapidly subsided after free transverse posterior incisions. The shaded outline shows the early callus.

TABLE OF SIXTY CONSECUTIVE CASES OF FRACTURE OF THE FEMUR.

Case No.	Name and Age	Days before Treatment	Days under Observation	Fracture	Treatment	Result
				Group 1.—No Wounds.		
1	D. F., 30	13	40	Oblique supracondylar	Transfixion 15 days; cradle splint 30 days ..	Good
2	J. L., 24	6	26	Comminuted middle..	Transfixion 17 days; plaster-of-Paris for transport	Good; union very rapid
				Group 2.—Clean Wounds.		
3	C. P., 22	13	59	Oblique subtrochanteric	Plaster extension 17 days; transfixion 24 days ..	Good
4	J. T., 25	14	61	Oblique subtrochanteric	Plaster extension 17 days; transfixion 25 days ..	Good
5	R. K., 35	7	66	Great comminution below trochanter	Transfixion 32 days; plaster extension 10 days; plaster-of-Paris for transport	Good
6	W. S., 20	14	24	Long oblique split ..	Cradle only	Good
7	A. L., 22	15	36	T-shaped intracondylar	Plaster extension; screw clamp extension 20 days	Good
8	A. D., 31	78	128	Oblique middle; 3 in. shortening	*Thomas knee-splint 78 days; double transfixion 28 days; single transfixion 7 days	Union incomplete
9	T. M., 20	6	51	Oblique middle ..	Transfixion 38 days	Good
10	J. R., 21	7	51	Oblique upper ..	Transfixion 31 days	Good
11	G. H., 21	7	33	Comminuted middle..	Transfixion 26 days	Good
12	T. T., 36	8	50	Comminuted middle..	Transfixion 30 days	Good
13	J. C., 20	36	78	Oblique upper; early malunion	*Abduction frame 30 days; 2½ in. shortening; transfixion (25 lb.) 35 days	Good
14	H. D., 32	36	78	Comminuted middle..	Transfixion 42 days	Good
15	G. D., 20	45	78	Comminuted upper; malunion	*Long Liston 42 days; great angulation, 3 in. shortening; osteotomy; transfixion 42 days	Good
16	V. S., 25	8	45	Much comminuted lower	Transfixion 26 days; plaster-of-Paris for transport	Good
17	A. E., 26	8	49	Oblique middle; 3 in. shortening	Transfixion 32 days	Good
18	J. R., 39	10	40	Long oblique middle	Transfixion 26 days	Good
19	M. D., 36	7	47	Much comminuted lower third	Transfixion 40 days; adhesive plaster extension for transport	Union incomplete
20	H. T., 19	22	50	Middle comminuted ..	Transfixion 30 days	Good
21	M. L., 21	19	52	Oblique into knee-joint, and tibia	Screw clamp extension 35 days	Good

* Treatment undertaken before the case came into the author's hands.

TABLE OF SIXTY CONSECUTIVE FRACTURES OF THE FEMUR, Continued.

Case No.	Name and Age	Days before Treatment	Days under Observation	Fracture	Treatment	Result
				Group 2.—Clean Wounds—*Continued.*		
22	J. T., 24	15	41	Oblique middle ..	Transfixion 24 days..	Good
23	W. P., 40	10	66	Irregular subtrochanteric	Transfixion 26 days ; plaster extension 30 days ..	Good
24	J. B., 22	6	42	Comminuted upper ..	Transfixion 31 days..	Good
25	W. C., 32	10	70	Comminuted upper ..	Transfixion 28 days ; plaster extension 30 days ..	Good
26	F. H., 28	8	70	Oblique middle ..	Transfixion 36 days..	Good
27	P. H., 19	8	50	Comminuted middle..	Transfixion 36 days..	Good
28	A. S., 25	4	34	Oblique lower ..	Tibial transfixion 20 days	Good
29	J. C., 30	8	63	Transverse upper ..	Transfixion 30 days. (At the time that the symptoms of dysentery became acute the femur had well united)	Died ; dysentery
30	H. L., 23	6	40	Comminuted middle..	Transfixion 27 days ; plaster-of-Paris for transport	Good
31	H. M., 25	16	49	Comminuted middle..	Transfixion 30 days	Good
32	J. C., 20	22	51	Comminuted upper and third	Transfixion 30 days	Good
				Group 3.—Slight Initial Sepsis.		
33	J. B., 34	7	—	Oblique below middle	Transfixion 41 days ; plaster extension and hinged splint 37 days ; plaster-of-Paris	Very slow union ; good form
34	W. W., 22	8	98	Oblique middle ..	Transfixion 36 days ; hinged splint 21 days ; amputation. (Sepsis had tracked up to the hip and down to the calf. It had invaded the knee-joint)	Loss of limb
35	T. W., 36	8	51	Oblique lower end ..	Transfixion tibia 35 days	Good
36	C. W., 25	9	62	Comminuted below trochanter	Transfixion 31 days	Good
37	J. R.	9	50	Comminuted above middle	Transfixion 34 days	Good
38	C. L., 25	7	82	Oblique below middle	Transfixion 64 days ; hinged splint 14 days ..	Slow union ; perfect form
39	H. M., 19	7	47	Comminuted middle..	Transfixion 26 days ; plaster-of-Paris for transport	Good
40	J. G., 43	14	58	Comminuted below trochanter	Transfixion 42 days ; plaster-of-Paris for transport	Good
41	R. W., 25	8	55	Comminuted middle..	Transfixion 39 days	Bone union good ; unhealed sinus
42	F. T., 34	9	55	Comminuted upper ..	Transfixion 35 days	Bone union good ; unhealed sinus

TABLE OF SIXTY CONSECUTIVE FRACTURES OF THE FEMUR, Continued.

Case No.	Name and Age	Days before Treatment	Days under Observation	Fracture	Treatment	Result
				Group 4.—Severe Sepsis.		
43	J. E., 19	14	114	Comminuted below trochanter	Plaster extension 23 days; transfixion 28 days ..	Deformity of bone; wounds healed
44	D. P., 40	89	120	Comminuted upper third	*Previous free bone removal; tibial transfixion 28 days	No union; wounds healing
45	W. H., 21	64	103	Comminuted upper third	*Plaster extension 28 days; *plaster-of-Paris 28 days; transfixion 35 days	Good; wounds healed
46	H. H., 19	30	88	Comminuted middle..	*Long Liston (3 in. shortening); transfixion 35 days; amputation for necrosis	Loss of leg
47	C. E., 25	5	5	Comminuted middle..	Amputation for secondary hæmorrhage	Death
48	J. M., 19	7	57	Oblique middle ..	Plaster extension 9 days; transfixion 23 days ..	Good union but lateral displacement; wounds healed
49	K. E.	60	111	Comminuted lower end	Thomas knee-splint, Hodgen splint, double inclined plane, 60 days;* transfixion 30 days	Good
50	P. R., 20	7	110	Oblique comminuted, upper and middle	Transfixion femur 36 days; transfixion tibia 42 days (knee-joint full of pus)	Death; sepsis, dysentery
51	J. H., 36	8	17	Comminuted lower ..	Transfixion tibia 7 days	Death: sepsis
52	A. M., 25	7	8	Comminuted middle..	Plaster extension 1 day	Death: second. hæmorrhage
53	T. H., 19	8	49	Comminuted lower ..	Plaster extension 11 days; transfixion tibia 25 days; plaster extension for transport	Bone result good; sinuses unhealed
54	C. H., 33	8	67	Comminuted middle..	Transfixion (10 lb.) 58 days; plaster extension for transport	Union not complete; sinuses unhealed
55	W. F., 25	14	29	Comminuted lower ..	Transfixion tibia (8 lb.) 2 days; amputation for gangrene due to primary wound of both popliteal artery and vein	Loss of leg
56	A. S., 20	6	72	Comminuted lower ..	Transfixion 63 days; plaster extension for transport	Union incomplete; sinuses unhealed
57	K. S., 30	8	39	Oblique lower into knee with fracture of tibia	Cradle splint; constant irrigation; amputation..	Death
58	W. A., 20	8	49	Comminuted middle..	Transfixion 37 days; plaster extension for transport	Union incomplete; sinuses unhealed
59	H. E., 20	8	49	Comminuted lower end with knee involvement	Transfixion tibia 31 days; amputation	Loss of leg
60	C. R., 21	7	39	Comminuted middle..	Plaster extension 32 days	Good bone form and union; wound not quite healed

* Treatment undertaken before the case came into the author's hands.

A CRITICAL REVIEW OF VARIOUS METHODS OF TREATING GUNSHOT FRACTURES OF THE FEMUR.

The different methods practised in the treatment of gunshot fractures of the femur may be grouped into three main divisions, and some of these further separated into subdivisions, depending upon whether the differences in the methods are those of fundamental principle, or merely of the details by which the principle is carried out.

1. *Simple Immobilization or Splinting.*—This may be carried out by (i) pillows or sand-bags, (ii) wood or metal splints, (iii) plaster-of-Paris.
2. *Open Operation.*—By plating, wiring, or screwing.
3. *Extension.*—This may be accomplished (i) without sling or splint, or (ii) by means of a sling splint. The latter may be used either with the knee straight and fixed extension, as with the Thomas knee-splint and its modifications; or with the knee bent and continuous extension, as with the Hodgen, Balkan, and the wire cradle splint. Continuous extension may be attached by (*a*) adhesive plaster, or (*b*) a transfixing pin.

(1) **Simple Immobilization or Splinting.**—This, making no allowance for dressing the wound without moving the limb, is a method which I think no one would choose or advocate. It was used early in the war simply because surgeons had not realized the necessity for special appliances, or did not possess them. It is still too often used on hospital ships, because of the simplicity of its demands on apparatus. I have never yet found anyone who justifies the method on its own merits, and therefore it is hardly worth discussing. But one point is so important that I must reiterate it. Supposing the transport of the patient from the field hospital to the base hospital only occupies a few days (three or four), is it worth while for this short time to place the limb on any special appliance?

Yes! a thousand times, yes! During this stage of transport the patient is subjected to a much greater liability to pain than at any other period, and in bad cases the spread of sepsis and the occurrence of hæmorrhage will be determined more by the inadequate slinging of the limb than by anything else. Again, it is in the stress and strain placed on the surgical and nursing staffs of a hospital ship that any labour-saving device is most needed; and the possession of such a device will often make all the difference between the possibility and the impossibility of shattered thighs being adequately dressed.

Plaster-of-Paris is used very little among English surgeons in the early stages of injury, and therefore it is hardly necessary to point out its dangers—concealing wounds, penning up discharge, and causing a risk of gangrene from a swelling of the part surrounded by the inelastic casing.

Later on, in a small proportion of cases plaster-of-Paris splinting is very useful in giving firmness to the thigh after the bone has once feebly united.

(2) **Open Operation.**—This method of treatment has fortunately found few advocates and still fewer followers. Apart from clean cases, or those of mal-union in later stages, when the open methods may often be adopted in exactly the same way as in the closed fractures of civil practice, it is dangerous in the extreme to employ it. The bone is much comminuted and the tissues are severely infected. To plate such a fracture requires the tissues to be widely opened up in order to get a good grip of the main fragments above and below the comminuted portion, and it involves infection of the deep tissues of the bone by every screw-hole. The result of such an operation will depend upon the virulence of the infection and the resistance of the tissues. In every case I have seen, the result has been a necrosis of the whole portion of bone which has been drilled, requiring amputation. The only argument in favour of an open operation is that it immobilizes the bone in a good position, and makes dressing and transport easy. It has already been shown that these advantages may be gained by the use of the cradle splint, without any risks.

(3) **Extension Methods.**—There is now great unanimity of opinion that extension is the cardinal principle which should be adopted in the treatment of gunshot fractures. This is so generally conceded, that the chief task of any critical examination of methods resolves itself into inquiry: (1) As to the efficiency and accuracy of extension; (2) To what extent the maintenance of extension is consistent with other principles, such as immobilization, freedom for dressing, and care of the muscles and joints.

Extension by Adhesive Plaster without Splint or Sling.—This method has the recommendation that no apparatus is required except plaster, bandages, and a weight. The adhesive plaster is taken above the knee as high as the wounds will permit, and the weight is hung over the end of the bed, the knee being slightly flexed over a pillow. There is so much hindrance to extension by reason of friction between the limb and the bed, that a heavy weight is necessary. But the fatal objection to the method lies in the fact that if a wound exists on the lower aspect of the thigh, the limb has to be raised for every dressing. This manœuvre causes great pain to the patient and disturbance to the bone, and imposes heavy work on the person who has to hold up the weighted limb while he keeps adequate extension upon it.

The method may be good enough for cases without, or with only trivial, wounds; but even in these it is open to the objection that it is very unsuitable for transport.

The Metal Splint with a Straight Knee.—Clearly it is necessary to sling the limb to a metal frame which will prevent sagging when the wound is dressed and which will supply a fixed point of purchase for the extension force. This, too, is generally accepted, and forms the basis of most of the present methods. Thomas's knee-splint may be taken as the type. In this, extension is made once and for all under an anæsthetic, counter-extension is obtained by a padded ring round the root of the thigh, and the knee is kept in a straight position.

The crucial point in the mechanism of a Thomas knee-splint for the treatment of a broken thigh is the fixed point for counter-extension. If a

single act of manual extension under anæsthesia is to place the bone in good position and keep it there, there must be two fixed points to which the two ends of the limb are attached, and these two points must not materially alter their relative positions for the six weeks to three months required for repair.

But the placing of a padded metal ring round the injured thigh at its junction with the pelvis to form a fixed point, is open to several objections which seem to me fatal to the success of the splint. It must fit well, and this can only be done by the patient being measured for his splint. Having been properly fitted, both as regards girth and obliquity, the ring lies in the gluteal fold adjacent to the anus, and becomes soiled with fæces, a point which is of special moment if the patient has dysentery or any form of diarrhœa. If there is a wound in the upper part of the thigh, the discharges from this will also foul the ring. Therefore the thigh ring must be changed from time to time, however carefully it is fitted, padded, and placed. But each time this is done the principle of fixed extension is violated, and a variable extension substituted for it. Further, if a sufficient pull be made on the leg to reduce the fracture, and be really maintained (this will amount to from 15 to 20 lb.), the pressure of the ring upon the perineum will become painful.

I have actually observed many cases of gunshot fracture of the femur treated by Thomas's knee-splint, but none seemed to be very satisfactory to both the patient and to a critical surgeon. They present one of two faults. Either the extension force has really been maintained, and the patient is sore and dissatisfied; or else the patient is content, the extension having been slackened, and measurement or the *x* rays show that malposition persists.

There are other criticisms, too, which must be made about the practical working of this type of splint. The extension force is obtained by a fixed band; therefore, when the limb is lifted or moved in any way for dressing, this band cannot adjust itself to the altered tension of the limb, and painful movement of the bone will occur. The knee must be kept straight; this implies two things: first, that the extension will have to overcome the full force of the flexor muscles; second, that the joint cannot be exercised until union is firm, say in about six weeks.

Page and Mothersole have each put forward splints which are essentially straight cradle splints like the Thomas, but without the thigh ring. This seems to imply that extension is not to be carried out continuously by their use, but merely immobilization during transport. Employed thus, all the splints of this group are very good, subject only to the drawback that they do not hold the limb up, so that dressing generally involves movement. Of the three patterns, the Thomas, the Page, and the Mothersole, that designed by Mr. Max Page is probably the best for this purpose, as it is efficient within the limits above mentioned, and it is easily improvised out of any malleable metal strips.

Wallace's splint is practically a Thomas knee-splint provided with a very powerful screw at the lower end, by which extension can be applied either by adhesive strapping or by a transfixing-pin. Clearly this is designed to be much more than a transport splint, and is intended for the final reposition of the bone. Mechanically there can be no doubt as to the efficacy of

this splint, whether it is used early or late in the treatment. But why provide an extension screw capable of exerting several hundred pounds' pull, when only 16 to 25 lb. is necessary? Whatever force is exerted on the distal part of the limb, there will be an equal and opposite pressure on the pelvic ring, and all that I have said above about the discomforts of the Thomas thigh ring applies equally to this.

Cradle Splints with Semiflexion of the Joints and Continuous Extension.—Of these the Hodgen splint must be regarded as the prototype, and from a purely mechanical point of view it is probably quite the best. The Balkan splint and the wire cradle splints which I have designed differ from the Hodgen, not in principle, but in minor details of practical importance.

The main principles of these flexed sling splints are :—

1. That the hip and knee are kept semiflexed, thus securing that position of physiological rest which the relaxation of the great flexor muscles produces. This means that the amount of extension required will be much less than if the joints are quite straight and the extending force has to overcome the maximum tension of the flexors. The limb being raised, dressing can be done without moving it each time.

2. That the extension force is a weight which acts constantly from the moment of its application until the bone has united, and will go on acting when hip and knee are moved, not being dependent on the immobilization of these joints.

And as a subsidiary, but still important principle, may be added—

3. That counter-extension depends partly on the body-weight, which holds the proximal fragment down when the limb is lifted up, and for the rest, upon a perineal band which acts upon the pelvis on the sound side. Thus, if the thigh is inclined at an angle of 25° to the bed, one-third of the counter-extension is taken by gravity, and the remaining two-thirds by the traction on the sound thigh. This tilts up the pelvis on the normal side, and secures that position of abduction which is so important, whilst allowing the two legs to lie side by side.

There is only one valid objection to this type of splint, namely, the tendency of suppuration to track up the thigh, which is favoured by the elevation of the leg. This tendency can be prevented by a sufficiently free opening and drainage of the infected area, together with the use of a rubber bandage above the wound. If these measures do not suffice, then the limb must be treated in a horizontal position, by the use of the hinged splint which I have described.

The differences in detail between the action of the three splints in this group are as follows :—

The Hodgen splint suspends the leg and keeps it swinging without other support than the extension cords which are attached to the splint itself. This involves a good deal of unintentional movement, which in the case of a complicated gunshot wound implies unnecessary pain. It is difficult to adjust it correctly, for suspension and extension being carried out by the same force, any alteration of the one implies alteration of the other. And, in common with the Balkan splint, it necessitates the patient being tied to his bed or to the uprights affixed thereto, and he therefore cannot be moved from his bed for *x*-ray or transport purposes until union has taken place.

The Balkan splint has the advantage of being capable of construction by any carpenter, as it simply consists of an inclined pole supported above the bed by two uprights, the leg being suspended to this by two or more slings. The pole above the patient is of advantage in giving him a fixed structure by which he can raise himself for the bed-pan. No objection can be raised to this splint on grounds of principle : it is both simple and efficient. But it has three drawbacks in practice. Like the Hodgen, it cannot be used for transport. The limb when slung is inaccessible for massage and movements. It is difficult to sling the thigh comfortably unless a single sling is used for that part of the limb, and when this is taken down for dressings, the wounded part sags.

The wire cradle splint, on the other hand, is self-contained, and it can be used as well on the deck of a hospital ship as in a base hospital. The whole of the front of the limb is free from bandages, and is readily accessible for massage and movements. Being constructed on the principle of the double inclined plane, it will support the thigh and maintain alinement without any weight extension, which can be applied at the desired moment.

The Manner of Attachment of the Extension.—This may be by adhesive plaster or transfixion for the final adjustment of the bone ; or by the other means I have described above for preliminary or later treatment.

Transfixion.—This question must be considered separately, because it can be used with any of the above splints. Its use has been illustrated so fully in this series of cases, that it is not necessary to do more than summarize the arguments for and against its use.

In Favour of Transfixion.—The method is infallible in the speedy and accurate readjustment of the broken fragments, so that the bone is of full length and correct alinement. Used with an appropriate sling splint, it can always be relied upon to place the bone in good position and to keep it there for six weeks. It causes less pain and discomfort both in its application, during treatment, and in its removal, than adhesive plaster.

Against Transfixion.—It certainly involves a risk of causing septic ulceration at the seat of transfixion; this, while a trivial matter in a healthy patient, may be of grave import in one who is debilitated by sepsis. The danger of septic complications does not lie in the transfixion of the bone, but of the soft parts about the knee-joint, where it may cause abscesses in the thigh or extension to the synovial cavity. These dangers may be lessened by strict attention to the details of technique above described, and by only using transfixion at a period when wound infection is being thrown off.

SUMMARY.

1. The treatment of gunshot fractures of the femur requires that the limb shall be immobilized at the earliest moment, and that this immobilization shall be such as not to interfere with frequent dressings.

2. These conditions are best carried out by a wire cradle sling splint constructed on the principles of the double inclined plane.

3. When the wounds have been thoroughly opened and drained by judicious transverse openings, and have taken on a healthy character, weight extension should be applied and maintained until union is firm.

4. Whilst weight extension can be applied by adhesive plaster or by transfixion, the latter is by far the more reliable, but is attended by certain risks of septic infection of the soft tissues, and particularly of the knee-joint.

5. When treated on the above principles, the results are as follows :—

Loss of life	10 per cent.
Loss of limb	6·6 „
Good form and function in limbs saved ..	74 „
Delayed union	16 „
Delayed healing	6 „
Deformity	4 „

6. The most important factor in the determination of the above results is the presence and degree of sepsis.

7. Comminution, apart from sepsis, is no hindrance but rather a stimulus to rapid union.

8. The removal of pieces of comminuted bone is unwarranted, and is the most potent cause of non-union.

9. Whilst all types of metal sling splints may give good results, those which, like the Thomas, require a fixed ring round the thigh of the broken leg, should only be used for transport—if the wire cradle splint is not available; for the thigh ring becomes soiled by fæces and wound discharges, and is a source of great discomfort to the patient.

10. Whilst the Hodgen, the Balkan, and the wire cradle splint all are correct in their principle of holding the leg in a position of semiflexion of the hip and knee, only the last is self-contained and can be used for transport; and further, it gives greater facilities for massage and movements than the other.

11. The position of flexion of the thigh entails the risk of encouraging pus to track up the limb; but this can be prevented by thorough opening of the infected area; or, if not prevented, it must be met by the use of a hinged splint which keeps the limb horizontal except for dressing, when it is elevated by a strut.

FRACTURES OF THE FEMUR AT THE CASUALTY CLEARING STATION.

By Surg.-Gen. Sir ANTHONY BOWLBY, K.C.M.G., K.C.V.O.

Compound fracture of the femur by gunshot wound has always been recognized as an injury which is most dangerous to life, and the experience of the present war entirely confirms the opinions formed in the past. Even when life is preserved many limbs are lost, and many which are not lost are severely crippled.

It is unfortunately true also, that these dangers are to a large extent inherent, and, although surgical skill can do much for many patients, there is a large minority in which it will not prevent the dangers to life and limb to which I refer. Even in civil life it is well known that such injuries are most serious; but in warfare the lesions are much more extensive and also much more frequently complicated. To begin with, the actual destruction of bone is infinitely greater in gunshot wounds, for in those inflicted by a missile travelling at great velocity, an inch or two of the bone, or even more, is sometimes completely shot away. Comminution is also far more extreme, and longitudinal or spiral fractures are much more common than in injuries due to machinery or street accidents. The fact is that the force which fractures the bone is greater in gunshot wounds, and the injury to the bone is proportionately worse.

The most important immediate complication is hæmorrhage. In the majority of cases this is severe, and is indeed very often the chief cause of death. It is the result of the injury to the soft tissues caused both by the missile and by the fragments of bone which are driven across the limb. It is least in cases where the injury is caused by a bullet at long range, for here the bone and the muscles escape the smashing which is caused by all bullets striking a big bone at the height of their velocity. In a considerable number of cases, large arterial branches are torn open, while the main femoral and popliteal vessels have been injured in many patients. It is, of course, not possible to ascertain the cause of death of men who die in the field; but, judging by the men who survive long enough to reach a field ambulance, it is probable that the laceration of the large vessels is the cause of death in many whom we never see in any hospital.

Complications of almost equal importance are found in the conditions in which the patient is wounded, and in the difficulty or impossibility of providing such immediate treatment as would be obtainable in all civilian accidents. In the first place, the patient is in muddy or dirty clothing and, if in a trench, he may fall into muddy water or deep mud. If he is hit during an attack, he is liable to be in so dangerous a position that he cannot be reached by stretcher-bearers, and many trenches are so exposed that the wounded in them can only

be evacuated after dark. It thus often happens that either no one can get to the patient to help him, or else that, even if he can be got at, he cannot be removed for complete surgical dressing and splinting for many hours; and when the dark has come, the removal from a deep and narrow trench and the carrying on a stretcher across slippery ground beset with shell holes and mud necessarily cause yet further pain.

One result of all that the patient has endured is that he arrives in most cases suffering from severe collapse, and in many men no pulse can be felt at the wrist for several hours after they have been placed in bed.

There is, however, yet another condition to complicate matters, namely, the presence of other injuries, and these are especially common when the fracture is due to injury by shell-fire. It thus happens that in many men there is fracture of another bone, or multiple wounds of the soft tissues in different parts of the trunk and limbs, and few such patients survive.

I found that the actual mortality of 1000 unselected cases in various casualty clearing stations was 160, or 16 per cent. But, as at least a quarter of these had multiple injuries, the mortality of the fractured femurs alone may be taken to be about 12 per cent. Of this number, there can be no doubt that the great majority died within the first twenty-four hours of admission, without rallying from their collapsed condition, and in some of these the main vessels would have been injured. In others, death within the first day or two was due to gas gangrene, and this has undoubtedly carried off many patients. In some of the number death followed amputation, which was either done soon after admission or else after trying to improve the condition of the patients, and after waiting twenty-four hours or more. Amputation has certainly saved many lives, but probably not much more than half of those operated upon, and it has been successful in proportion as it has been performed for injuries in the lower part of the thigh.

Whether treated by amputation or not, the fractures in the upper part of the thigh have certainly on the whole been more serious and fatal than those lower down, but the fatality has in some cases been due to complications caused by the bullet passing on into the pelvis and fracturing the ischium or pubes.

I have found it very difficult to ascertain for certain how many patients die with fracture of the femur on the field or in the field ambulances, but I believe that the numbers would amount to about an additional 2 per cent, raising the mortality at the front to about 14 per cent.

TREATMENT.

In considering the treatment of these injuries, it is evident that one can only speak in general terms, because of the very great variety presented; and, as I am only concerned here with treatment at the front, I shall not attempt to deal with the problems which present themselves at a later period. What would, I think, strike any observer who considers the extreme difficulty of rescuing these men from close to the enemy lines is the expedition with which they are brought to the rear, and the care and thoroughness of their first dressing and splinting. The skill and care shown by the orderlies in loading or unloading ambulances must be seen to be appreciated.

In almost all cases it is advisable to let the patient rest quietly for two or three hours, so that he may get over the tiring effects of his journey, before attempt is made to dress the injured limb, and in some cases where collapse is more severe it is often necessary to wait longer, until the patient has taken enough food to restore his strength. In some cases the administration of saline solution by the subcutaneous or the intravenous method is necessary, but this may often be advantageously postponed till the dressings are changed.

If the fracture is of no great severity, and is caused by a missile which has made but slight wounds, it is generally best merely to change the dressings and see that the limb is on a suitable splint, and then send the patient direct to the base. Unfortunately such cases are few in number, and it is the rule in most clearing stations to administer an anæsthetic in all cases of bad fracture and extensive wounds, and to open up and cut away damaged tissue and skin, and establish free drainage, before finally adjusting the limb on a suitable splint. After this has been done, the patient should be sent to the base within the next forty-eight hours if his condition is satisfactory, for there is then nothing to gain by keeping him for a few days near the front, where the constant inflow and passage of new patients occupies everyone so constantly that there is often hardly the necessary time to spend on prolonged dressings.

In all cases where shock is severe, the question of anæsthesia is of much importance. I am convinced that chloroform should not be used, and open ether has been the usual anæsthetic, and has given satisfactory results. Within the last two months, however, we have used at many of the clearing stations "the apparatus for the administration of warm anæsthetic vapours," described by Dr. Shipway in the *Lancet* for January 8, of this year. This was obtained by Capt. Marshall, and used at No. 17 Casualty Clearing Station with such good results that we have used it in other stations to take the place of open ether. It possesses the great advantage that it causes practically no secretion of mucus by the trachea and bronchi, and, as a consequence, it is of great value in the many cases where patients already have bronchial catarrh from exposure to cold and wet. In other cases, where shock is severe, the 'intravenous' use of ether has great advantages, for it enables the administrator to give the anæsthetic in combination with several pints of normal saline solution.

Intraspinal anæsthesia by the use of stovaine has been practically given up in these cases after a careful trial. However useful it may be in many other conditions, it is dangerous to employ it where there is much collapse, for it is itself liable to cause depression, and I have known two patients die soon after it was injected, and before the amputation had been commenced.

The treatment of the wound itself may be summed up as thorough cleaning, combined with cutting away of the torn skin edges and ragged muscles and the provision of free drainage. For some months past the worst cases have been treated by constant irrigation with eusol for several days prior to sending them to the base, and it is the general opinion that this treatment has been of much service.

In regard to the fractured bone itself, it seems clear that all very large fragments should as a rule not be removed, for they are seldom absolutely

loose and devitalized. Small fragments, if completely detached, should be removed; but so long as they have any attachment to muscle or periosteum they should certainly be left. At the beginning of the war there was too great a tendency to remove bone. The use of plates, screws, and other mechanical contrivances is to be strongly condemned. They all set up osteitis, and, as the bone becomes rarefied, they become loose and act as foreign bodies. They are not only useless, but very dangerous.

Splints.—These have undergone a complete metamorphosis since the beginning of the campaign. The army 'Fracture Boxes' contained only some plain Liston's splints without brackets. These were not only too slender, but they also had to be removed when the wound was dressed, to the great discomfort of the patient. We soon were supplied with 'bracketed' or 'interrupted' splints, and used them for some months. These, in turn, have given way to various forms of metal skeleton splints, the chief of which are the Robert Jones modification of the Thomas knee-splint, the Wallace-Maybury splint, and the Page splint. All alike aim at a bearing on the tuber ischii and the pelvis, and a steadying of the fracture by extension. They have been of the greatest possible service, and are far the best form of apparatus for use near the front, and for conveyance in ambulances and trains. A further gain in comfort has been obtained by the use of the 'stretcher suspension bar' of Col. Cuthbert Wallace and Major Frankau. It is clipped on to the stretcher at about the level of the ankle, and the splint is then slung to it so as to be clear of the stretcher. All the clearing stations and the hospital trains are supplied with these suspension bars, and, while in transit, the patient is never moved off the stretcher on which he lies in the clearing station. He goes on it into the ambulance, the train, the ambulance at the detraining centre, and so to the base hospital. In this way he is saved a very great deal of pain, the limb is kept much more steady, and the fracture is much less disturbed than by any other method. In fractures near the trochanters and with wounds in or near to the buttock, these splints cannot be used, and the 'Bracketed long Liston' is then employed.

Amputation.—This is almost invariably necessary if the femoral or popliteal vessels have been wounded, and the complication is unfortunately a common one. I have no figures to show its proportional numbers, but there can be no doubt of its great frequency, for I have myself seen at least thirty or forty such cases which reached the clearing stations.

Comminution of the condyles with involvement of the knee-joint is another chief reason for amputation, and in very few such cases ought any attempt to be made to save the limb.

The third reason for amputation is extensive tearing and destruction of the skin and muscle. This may be so severe as to result in an almost complete severance of the limb; but in many other cases such large portions of the front or back of the thigh are torn off that it is evident the limb would be useless even if it could be preserved. In most of such cases, if an attempt is made to save the limb, gas gangrene supervenes and the patient quickly dies; or, if he escapes this complication, the extensive suppuration and sloughing of the huge wounds cause a rapidly fatal sepsis.

It is well known that the mortality of all amputations for trauma increases

in proportion as the limb is removed high up, and this is certainly true of the cases under consideration. Few patients survive removal in the trochanteric region, and I have not known one recovery after amputation at the hip-joint. It must, however, be said at once that this operation is practically never per formed, and it is one I have never advised. When one considers the virulent sepsis which is rife in all these extensive wounds, and the vast surface of muscle and cellular tissue exposed in amputation at the hip, it is evident that one would not expect such an operation to succeed in men who are already severely collapsed.

The time at which amputation should be performed is often a very difficult question to decide, and experience of such cases is very valuable in coming to a decision. I will describe briefly a typically difficult case.

An officer was shot by a bullet which split his femur from front to back and from above downwards, opened the knee-joint, and emerged at the bottom of the popliteal space. He was very much collapsed when brought from the field ambulance after about fourteen hours. His foot and leg were quite cold and numb, and it was almost certain that his popliteal artery had been divided, although there was neither swelling nor hæmorrhage. He was, however, almost pulseless, and, though it was evident he must lose the limb, I decided not to amputate then. Next day he was still too ill to touch. After forty-eight hours had elapsed he had rallied, as a result of frequent feeding and the judicious use of sedatives and stimulants, and he made a good recovery after removal of the limb in the lower third of the thigh. A subsequent examination showed a T fracture into the knee-joint, and complete destruction of an inch or more of the popliteal artery. His collapse was such that he would certainly have died if the operation had not been delayed, and yet it appeared also very dangerous to leave him with a gangrenous limb. These are very difficult cases; and especially when there is very extensive laceration of the muscles and a huge wound, it is best not to be in a hurry to operate so long as bleeding can be arrested. It is true that patients of such a class will often die before an operation is done; but that does not imply that an operation should have been done; and, on the other hand, I have seen patients improve so satisfactorily that one was able to wait even three or four days, and then remove the limb in comparative safety.

Indeed, I have been much impressed with the need for delaying amputation in most of the cases where it is hopeless to try and save the limb; but there are of course many cases where the conditions require that the shattered remains should be removed, and it then becomes a question what sort of operation should be performed. It must be realized that these cases, where the limb is hopelessly shattered, are the very ones in which collapse is at its worst; for when a leg has been nearly shot away, a great majority of the patients die, and the few who remain long enough alive to allow of their getting to a clearing station are also very near to death. In such as these, the only possible operation is to sever the remaining tissues and cut away the projecting bone without attempting to do more, for a formal amputation higher up would inevitably be fatal at once. Few of the worst of such cases can survive; but, as there is every gradation in the amount of shock and the extent of injury, it is possible to save a certain number. In all such stumps there is a great deal

of dead and partially devitalized tissue which is always also badly infected, and as a result of these conditions, there is invariably some sloughing in the stump.

There are many surgeons in England who are unacquainted with the conditions at the front and with those of the recently injured men, and who express surprise at the unhealed stumps, and consider that such things ought not to be. They should hesitate more than they have done before they condemn work which they do not understand; for the men whom they see represent the survivors of those whose lives might well have all been despaired of, and their recovery has only been ensured by prolonged and untiring effort. It is indeed difficult not to give up hope in pulseless and collapsed patients, considering how many die in spite of every effort. But it is to the credit of surgeons, nurses, and orderlies alike that, undiscouraged by frequent failures, they stick to their patients, and feel amply rewarded when they succeed in pulling them through.

In other cases, where the soft parts have not been so very extensively injured, amputations can be performed by more recognized surgical methods. It is, however, unwise to cut long skin flaps, such as one may do in aseptic conditions in civil practice; for, in the presence of sepsis, sloughing is of frequent occurrence, and it may be quite impossible to perform an amputation clear of all sepsis, for there are frequently other wounds higher up the limb or in the buttock. And even when there are no such wounds, the muscles are often torn far above the seat of fracture, and all the torn pieces cannot be removed except by incurring the risk of amputation of the limb at a very much higher level.

GUNSHOT FRACTURES OF THE FEMUR.

By Major E. K. MARTIN, R.A.M.C. (T.C.).

This paper is based on the fractures of the femur which have been treated at a base hospital in France from November, 1914, to February, 1916. Most of the cases came from the Ypres and Neuve Chapelle sectors; in the earlier months they were received from two to four days after being wounded, from March, 1915, onwards, twenty to thirty-six hours afterwards.

During the latter part of 1914 there was little leisure to keep records of the large number of cases which passed through the hospital, but I have clinical notes of 52 admitted between March, 1915, and January, 1916. In 9 of these cases the degree of sepsis was so slight that they were only kept while awaiting evacuation, the average stay being four days; these have not been traced. In 3 of the remaining 43, entry and exit wounds were clean rifle-bullet punctures, necessitating no treatment beyond the fixation of the fracture. The remaining 40 cases all had lacerated, septic flesh wounds leading down to fractures of varying degrees of comminution; 10 of these died in France, and 5 more died later in England.

The causes of death were as follows:—

		Period since wound.
In France—		
Gas gangrene	6	2–7 days
Secondary hæmorrhage ..	1	33 ,,
After amputation for sepsis	1	19 ,,
Streptococcal septicæmia ..	1	23 ,,
Pneumonia	1	16 ,,
Total ..	10	
In England—		
Pyæmic abscesses.. ..	1	44 days
Wounds and enteric ..	1	44 ,,
Streptococcal septicæmia ..	1	90 ,,
Sepsis	1	11 months
Following re-fracture ..	1	12½ ,,
Total ..	5	

The 52 cases may therefore be divided into three groups: (1) 12 cases with clean or very slightly infected wounds—no deaths; (2) 6 cases with gas gangrene which proved fatal within a few days of admission—these were hopeless from the first; (3) 34 cases of septic comminuted fracture needing prolonged drainage—of these 4 died in France and 5 in England, an immediate mortality of 12 per cent in France, and an ultimate mortality of 26 per cent. It is the last type of case with which treatment at a base hospital abroad is specially concerned.

In any discussion of gunshot fracture of the femur, the first essential is to lay down the limits within which lie the particular group of cases under

consideration. Many die before reaching the base hospitals in France; others with little or no infection are sent straight through to England. It is the intermediate group lying between these extremes with which this communication deals.

The clinical course of any given case depends primarily on the nature of the missile, its mechanical effect on the bone and soft parts, and the degree to which it infects the tissues during its passage. Other factors of secondary importance are—the time which elapses before the man can be brought in and before fixation can be applied, and the degree of additional trauma during transport to the base. The types of wound met with must be considered from two points of view—viz., the mechanical effects of the trauma on the bone and soft parts, and the character and degree of the infection introduced.

THE WOUND OF THE SOFT PARTS.

Nature of the Missile.

1. *Rifle Bullet Undeflected.*—The wounds of entrance and exit are both clean punctures, and the septic element is absent.

2. *Rifle Bullet Deflected by contact with Bone.*—The entry wound is a clean puncture, but the exit wound is a ragged track in muscle ploughed up by a bullet which is rotating on its short axis. The laceration of muscle is often increased by flying fragments of bone, in which case the exit wound may be of any size up to half the length of the thigh. The damaged muscle may become infected secondarily from the skin and clothing, but no clothing or gross dirt is present in such a wound.

3. *Shrapnel Bullet.*—A shrapnel bullet in passing through the equipment punches out and pushes before it a wad of cloth, etc. If undeformed, it drops this wad during its passage through the tissues, and may do so at any point from the skin opening to the bone. If the bullet is deformed, a portion of the wad is likely to adhere to it. Owing to its slight power of penetration, a shrapnel bullet frequently remains in the immediate vicinity of the fracture; or in the case of cancellous bone, embeds itself without producing a complete fracture. As shrapnel bursts in the air, the bullet does not carry in any mud, apart from that adherent to the particular portion of equipment pushed in front of it.

4. *Shell.*—Fragments of high-explosive shell or bomb-casing, and deformed ricochet rifle-bullets, also strew fragments of clothing along their track; but being rotating missiles of irregular shape, they acquire a closely adherent coating made up of the various layers of equipment through which they have passed. As a rule, high-explosive shell bursts in the ground; consequently every fragment passes through a layer of earth before penetrating the skin, and thus carries with it that mass of organisms of essentially fæcal origin which so deeply colours the clinical picture. Lastly, shell, bomb, and grenade wounds are frequently multiple, adding greatly to the chance of generalized anaerobic infection. As is well known, it is the fragment of clothing which constitutes the infective agent, thus necessitating the removal of almost all foreign bodies associated with a fracture.

Removal of Foreign Bodies.—For the reason just given, all foreign

bodies of irregular shape are removed as soon as they have been adequately localized. Undeformed rifle bullets, with clean punctured wounds of entry, are left *in situ* unless interfering with the movement of a joint. In this case they are removed when the wound has healed and the surrounding tissues have recovered from the mechanical trauma. Shrapnel bullets embedded in cancellous bone or in peri-articular tissues are left undisturbed, so long as they remain quiet. The longer their course in the body, the more likely they are to have dropped their attendant wad of clothing, and so to have become innocuous.

Operative Technique.

Rifle-Bullet Wounds.—Clean rifle-bullet punctures are not interfered with, except when it is necessary to make use of them for the purpose of gravity drainage.

Ragged exit wounds from a rifle bullet which has entered through a clean puncture, are only infected secondarily, if at all, from the skin and clothing. This infection may readily spread to the fracture along the lacerated skin and muscle, but its clinical rate of progress is slow if left alone. On the other hand, the introduction of a drainage tube necessarily carries organisms from the superficial parts of the track direct to the bone, where their development is encouraged by the presence of a foreign body. By the insertion of such a tube the conditions in the wound are changed from the rifle-bullet to the shell type, and no chance of escape from the ordinary course of suppuration is allowed. The superficial part of such a track is therefore treated by the method advised by Col. H. M. Gray—i.e., it is excised, and the wound loosely packed up to the skin surface with salt citrate tablets in gauze. This pack is not disturbed for several days, the dressing over it being changed as often as may be necessary. Rifle-bullet fractures whose exit wounds are treated in this way within forty-eight hours, rarely give trouble.

Lacerated Septic Wounds.—The surrounding skin is first disinfected with 10 per cent iodine in spirit, the wound is dried out with gauze, and then packed with gauze soaked in 10 per cent iodine solution. After a few minutes this is removed, and the wound gently explored with the finger to ascertain the presence or absence of lateral pockets.

Cylindrical Track without Pockets.—The walls of such tracks consist of lacerated infected muscle, which will slough to an average depth of a quarter of an inch, and which forms an ideal culture medium for organisms. The diameter of the opening in the skin and deep fascia is less than that of the cylinder of damaged muscle, and readily becomes plugged by the swelling of the latter, thus insuring suitable conditions for the growth of anaerobes.

The whole track is therefore excised, with a quarter-inch margin, so as to approximate to the hole left by a cork borer; and a drainage tube of perforated rubber or metal, large enough to fill the wound, is put down to, but not through, the fracture.

Irregular Track with Lateral Pockets.—The same general plan is followed, the pockets being slit up if short, or opened through to the skin at the blind end if long. Through this opening a tube is led down to a lateral aperture in the main tube. Lacerated muscle in the walls is trimmed off as far as possible.

Irregular Lacerated Exit Wounds of the so-called 'Explosive' Type.—These are dried out, iodined, and the superficial layer of damaged tissue trimmed off. The conical cavity is then filled with a salt citrate pack, with a central tube incorporated in the dressing for drainage when the wound is at the back. In every case gravity drainage is established. Where a posterior wound does not exist, a drainage tube of half-inch bore is passed up to the fracture through an incision parallel to the fibres of the underlying muscle. This incision is three times the diameter of the tube, so that its walls grip the latter. If the opening in the skin and deep fascia is smaller than that in the muscle no herniation of muscle is possible. If the opening in the skin and deep fascia is larger than that in the muscle, herniation of the latter is apt to occur. Cutting through muscle fibres at right angles to their long axis results in retraction of the ends, with the formation of a pocket, and may lead to extensive infection of the muscle belly.

Infection by Gas-producing Anaerobes (Gas Gangrene).—All septic wounds from the Flanders front contain streptococci and gas-producing anaerobes as their main flora. The latter organisms usually dominate the clinical picture of the wound during the first few days, and give rise to a chocolate-brown discharge from the damaged muscle. Where the skin opening is much smaller than the cavity inside, as in wounds produced by small fragments of shell of high velocity—especially those which carry in much dirt (e.g., from a blown-in dug-out)—or by a bomb, anaerobes are apt to develop with great rapidity, and produce the clinical picture of 'gas gangrene.' Cases where a few bubbles of gas are present in the discharge from a foul cavity should not be included in this category, unless there is evidence of extension beyond the immediate area of damage.

The anaerobic spread takes place along two distinct planes, subcutaneous and subfascial, and the predominance of one or the other determines the degree of toxic absorption, and the treatment necessary to check it.

Subcutaneous Gaseous Cellulitis.—This is a painless cellulitis, the subcutaneous tissue becoming infiltrated with anaerobic organisms, œdematous, and of a brown colour. The infection does not penetrate the deep fascia apart from the wound, and does not cause enlargement of the glands in the groin.

On the surface, it shows as a chocolate-brown discoloration of the skin, with, later, superficial gas bubbles. Before these are large enough to give a crepitant sensation to the finger, they may often be appreciated in the *x*-ray negative, where they appear as longitudinal slits immediately deep to the true skin. The discoloration spreads more rapidly in the long axis of the limb than transversely.

In rare cases this subcutaneous gaseous cellulitis is superimposed on a purulent infection of the deep fascial lymphatic plexus. This is recognizable clinically by a tenderness of the skin (not present in gaseous cellulitis), and a tender enlargement of the glands in the groin. In this type, yellowish-white pus may be present within thirty-six hours of the infliction of the wound, both on the superficial aspect of the deep fascia, and between this and the underlying muscle. In combination with a gas infection, it is a condition of extreme gravity.

Subfascial Gas Gangrene.—It is only when the spread of the anaerobic

organisms takes place within the inelastic envelope of the deep fascia that actual gangrene of the limb is produced. Gas gangrene is the resultant of this extension, and of the strangulation of the blood-supply by the consequent tension within the cylinder of deep fascia. The main vessels are not thrombosed unless injured by the missile.

In the earlier stages of anaerobic infection, before actual gangrene of the limb takes place, the damaged muscle and blood-clot in the wound break down rapidly to form a foul-smelling brown discharge in which bubbles of gas are present. Spread takes place along the bellies of damaged muscles, which become œdematous and dark brown in colour, and along intermuscular fascial planes, which liquefy and allow tracking of the characteristic brown discharge.

Any impairment of the venous return is at once reflected in an increased rapidity of anaerobic extension. This is well seen on the inner side of the thigh when a perineal band has been applied. In all cases the pressure of the weight of the limb on the splint or bed encourages the gangrenous process to advance more rapidly up the posterior than the anterior aspect of the thigh.

In consequence of the development of deep gas infection, the thigh becomes tightly distended and tympanitic. The subcutaneous fat acquires a greenish tinge, which shows through the pale stretched skin and gives the characteristic mottled appearance, in which the superficial veins stand out clearly. In the neighbourhood of the wound where subcutaneous gaseous cellulitis is present, the chocolate brown of the latter predominates.

General Results of Gas Gangrene Infection.—Subcutaneous gaseous cellulitis may extend to thirty or forty square inches without causing any unusual rise of temperature or pulse-rate. The presence of any serious degree of subfascial spread, on the other hand, is always reflected in the patient's general condition.

Increased pulse-rate is of much greater significance than rise of temperature. The latter may be negligible even when the condition of the limb is so grave as to necessitate amputation. The most serious cases show an acceleration of pulse-rate of twenty or thirty beats a minute per hour, accompanied by a temperature rising rapidly to 102° or 103° and falling abruptly with the onset of gangrene. Jaundice occurs, varying from a slight discoloration of the conjunctiva to a deep yellow staining of the whole skin in the most serious cases; it is accompanied by hæmolysis. Repeated vomiting is sometimes difficult to control, and hiccough is met with as a terminal phenomenon.

In fatal cases, gas-forming anaerobes invade the blood-stream a few hours before death, and occasionally give rise to metastatic gaseous cellulitis at the site of mechanical injury (e.g., simple fracture, subcutaneous saline infusion).

Treatment of Gas Gangrene. *Subcutaneous.*—Free incision down to, but not through, the deep fascia is always sufficient. The incisions should be three-quarters of an inch to an inch in length, in the proportion of one to every three or four square inches of brown skin. It is not necessary to go beyond the limits of the brown discoloration. Vertical incisions are as efficient as transverse, and have the advantage of causing no unnecessary damage to cutaneous nerves.

After incision, there is a free discharge of fluid of a bright saffron-yellow colour. Lymph lavage is encouraged by dressings of 5 per cent hypertonic

saline (Wright); and as soon as the fat becomes healthy in colour, all the incisions are sewn up with one or two loose stitches each. This is usually done on the fourth day, and is followed by union at the end of a week.

Subfascial.—a. Localized to immediate neighbourhood of wound: The wound is excised more freely than usual, and further incisions are made through œdematous or discoloured muscle on the same plan as for subcutaneous spread—i.e., a number of small rather than one large opening.

b. Distended tympanitic thigh without actual gangrene and with moderate general intoxication (i.e., pulse not above 120 and of good volume, jaundice slight): Amputation is performed immediately. It is true that many of these cases can be saved for the moment by very free muscle incisions. The exposure of a large area (forty to sixty square inches) of muscle fibre to the action of the accompanying streptococcus is, however, apt to lead to such severe sepsis as to necessitate amputation later, at a time when the patient is less able to withstand the shock of the operation than he was when first seen.

c. Actual gangrene, or cases with profound general intoxication: Immediate amputation.

d. Tympanitic thigh, gangrene of the limb, and a brown skin-discoloration extending on to the trunk: These cases, however grave the general condition, are treated by amputation at whatever level necessary, and free incision of the area of subcutaneous extension. I have seen two successful cases of this type.

THE BONE LESION.

Indirect Violence.—In certain cases of spiral fracture of the shaft, with punctured wounds of entry and exit, it is probable that the fracture is due to indirect violence, and is really caused by the fall or the muscular contraction which follows the impact of the bullet. I have admitted one case of this type.

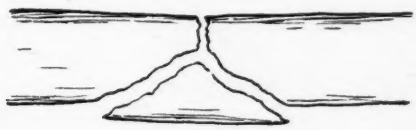


FIG. 241.—Transverse fracture of the femur caused by a shell wound, with displacement of a triangular fragment from the side opposite to the point of impact.

Comminution.—In the absence of infection, comminution, both of compact and cancellous bone, is a negligible factor in early treatment.

Comminution with Infection.

1. *Compact Bone of Shaft: Comminution slight.*—A shell fragment of low velocity produces a transverse fracture, and knocks out a triangular fragment from the side opposite to the point of impact (*Fig.* 241). A single fragment of this type is removed subperiosteally for two reasons: (*a*) No foreign body is left in the wound; (*b*) Drainage of the fracture is ideal, as a track can be made direct from the open bone to the surface (*Fig.* 242).

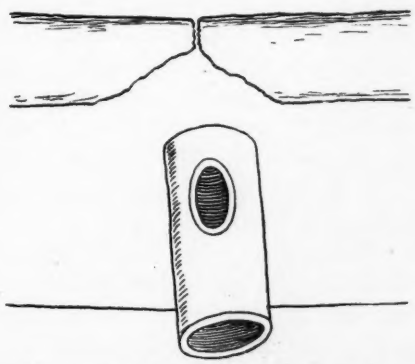


FIG. 242.—The fragment removed, and a drainage tube inserted down to the bone.

2. *Compact Bone of Shaft: Comminution severe.*—While the problem of how much loose bone should be left has not yet been solved, there are two types of case in which the advisability of removing loose fragments is clearly established: (*a*) First of all, there is no doubt that any given segment pulverized may be regarded as lost, the small fragments, if left, coming away by degrees in the discharge. As this entails long-continued sepsis, with its attendant dangers, loose bone of this type is better removed at once, and extension maintained with a view to union with an amount of shortening corresponding to the length of shaft pulverized, or possibly grafting when the acute infection has subsided. The practice of removing loose fragments, washing them in saline, and replacing them, has not been found to prevent their ultimate discharge. (*b*) In the second place, all pieces of bone blown into surrounding muscle are removed. These invariably give trouble if left.

The largest group of cases, and that about which opinion has been most divided, comprises fractures in which one or more large and a number of small pieces bridge the gap. Here it is reasonable to assume that the larger fragments have suffered less mechanical trauma than the smaller ones. If such a fracture is pieced together, it is found that the smaller fragments are derived from the immediate vicinity of the point of impact, and for the most part have lost their periosteal connections. They are portions of bone which have suffered severe mechanical trauma, associated with a diminution of blood-supply, and should be treated precisely as any other damaged tissue such as muscle or skin, namely, by excision. A chain of the larger fragments with periosteal and muscular attachments is therefore left, and the small loose pieces are removed.

When the point of impact can be identified without additional exposure, its edges should be excised as in a wound of soft parts.

3. *Shaft: Foreign Body retained in the Medullary Cavity.*—While it is quite common for a shrapnel bullet or a fragment of high-explosive shell to remain loose among the fragments of the bone it has shattered, no special harm results to the bone itself on this account, as the path of least resistance for the products of infection is along the track of entry and into pockets among the torn muscle fibres. The open ends of the shaft become plugged by swollen and sloughy medulla, and infection does not spread more than half an inch along the bone. Acute osteomyelitis of the shaft, as met with in civil practice, does not occur; and even chronic osteoperiostitis, as shown by thickening of the whole length of the shaft, is uncommon within the first month (2 cases in 52 fractures).

Retention of a septic foreign body in the medullary cavity, without complete solution of continuity of the bone, is uncommon. I have seen no example of this condition in the femur. In the tibia it has given rise to a fatal anaerobic osteomyelitis, the whole medullary cavity being converted into a black foul-smelling mass.

4. *Cancellous Bone.*—(*a*) *Extra-articular Lesions*: By reason of its structure, cancellous bone is quite different from compact bone in its behaviour towards missiles of relatively low velocity. Like compact bone, it is completely shattered by a rifle bullet of high velocity; but partially spent rifle bullets, all shrapnel bullets, and small fragments of high-explosive shell, tend to drill a hole

through it rather than produce a complete solution of continuity. Where the missile has not sufficient momentum to perforate the whole thickness of the bone, it embeds itself without producing more than local disturbance of the trabeculæ.

The effects of this kind of injury depend on the infectivity of the material carried in; but operation and post-mortem examination show that the surrounding osteitis is usually limited to the damaged trabeculæ, and does not extend to uninjured bone. Operations for the relief of sepsis, therefore, need not go beyond the radiographic limits of the damage; and missiles in close proximity to joints may be left *in situ* so long as they are quiescent, with a view to their removal, if necessary, when the limits of the damaged and infected tissues are better defined.

Lacerated wounds of the outer part of the great trochanter are excised, together with the damaged portion of bone, and the limb is fixed so that rotation cannot bring the bone wound under cover of the skin or iliotibial band. A cylinder of perforated zinc sheet (Captain Wm. Anderson), of diameter greater than the bone wound, and in depth equal to the distance from skin to bone, is then stitched in to retract the soft parts, and is filled with a gauze pack containing tablets of sodium chloride and sodium citrate, as suggested by Colonel H. M. W. Gray. The cylinder is removed as soon as granulation is established, and the wound is allowed to close.

(*b*) *Intra-articular Lesions: Hip-joint.*—In the case of small foreign bodies embedded in the head or neck of the femur, particularly when the entry is behind, it is quite safe to fix the joint, excise the wound cylindrically, and drain down to the bone. The case may then be watched until an estimate can be formed of the degree of infection present.

Severe comminution of the cancellous tissue of the head, in presence of ordinary mixed infection, if left with simple drainage, soon results in erosion of the acetabular cartilage, with tracking of pus and the conversion of the fragments into greenish-yellow sequestra. Such an injury necessitates excision of the whole head and any damaged portion of the neck through a posterior incision. Free gravity drainage is established, and the limb is fixed in wide abduction. No other procedure gives adequate drainage of the hip-joint.

Knee-joint.—Fracture of the intra-articular portion of the femur derives its importance so peculiarly from the involvement of the knee, that any discussion of injury to this part of the bone *quâ* fracture may be limited to the statement that shattering of both condyles is treated by primary amputation.

As is well recognized, an effusion into the knee-joint may accompany fracture of any part of the shaft of the femur. It has no tendency to become infected, unless there is a crack extending down into the joint from a septic fracture.

FIXATION.

A fractured femur with an open and infected wound presents two major problems, fixation of the fragments, and treatment of the sepsis. Up to the end of 1914 the interdependence of the two was not generally recognized, and attention was concentrated mainly on the problem presented by the wound itself. The limb was usually suspended from an overhead frame (Balkan)

by slings which could be let down locally to allow of access to the wound, extension being applied by weight and pulley.

As the time of transport to the base became shorter, the wounds began to arrive in better condition; and with the diminution in urgency of the sepsis, a more just appreciation of the paramount value of fixation became possible. Early in 1915 the principle of fixed extension began to take rightful predominance over all forms of weight-and-pulley extension; and for the last twelve months, with a few exceptions in special cases, all fractures of the femur have been treated on Thomas's knee splint, or on Robert Jones's frame, where abduction is required.

After twelve months' experience of the various modifications of the Thomas splint (the Wallace-Maybury and the Page are the best known), I am convinced of the superiority of the original pattern, as being at the same time the simplest and most efficient. A great addition to its power of fixation is the substitution of perforated sheet metal for the usual slings, an improvement introduced by Major M. Sinclair. The best form of weight extension is the Hodgen; but, in my experience, it does not bear comparison in any way with the fixed extension splints.

The choice between the Thomas knee splint and the Jones abduction frame turns entirely on the position of the upper fragment. Roughly speaking, the former splint is suitable for all fractures from the junction of the upper and middle thirds of the femur to the junction of the middle and lower thirds of the tibia. The comfort of the patient is greatly increased by the methods of suspension introduced by Major M. Sinclair (*Journal of the Royal Army Medical Corps*, July, 1915). The use of fixed extension splints necessitates attention to several points of detail, which have been so fully described by Major Robert Jones as to render their repetition superfluous. By means of the Thomas knee-splint or Jones abduction frame any fractured femur case can be maintained in good position and of satisfactory length, provided that multiplicity of wounds does not prohibit the application of adequate extension. Shortening is directly proportional to the loss of bone, whether this is blown out, removed at operation, or discharged with the pus. In presence of free suppuration, half to one inch may be regarded as the average.

A very limited experience of the results of early mechanical fixation of the fragments in comminuted fractures, with the ordinary mixed infection met with in France, is enough to convince one of the inferiority of such methods in comparison with external fixation by splints. The objections to the introduction of foreign bodies into the infected area itself are obvious.

Of the results of applying extension through a transfixion-pin at a distance from the wound, I have no personal experience. In view, however, of the difficulties of prophecy as to the likelihood of a streptococcal invasion of the blood-stream in any given case, I should hesitate to risk the insertion of a foreign body into clean bone for the sake of a problematical advantage.

IRRIGATION.

For the first two or three weeks of a septic compound fracture, continuous mechanical washing away of pus and sloughs would be by far the best treatment. Though ideal, this is unfortunately impracticable, because of the

difficulties in the provision and disposal of the immense quantity of fluid required. To be efficient, irrigation must take place at a pressure sufficient to distend and clean out all crevices; the usual trickle which is dignified by the name of continuous irrigation does little more than wash a narrow channel along the floor of the wound and some inches of drainage tube. It is best carried out under the guidance of hand and eye, with a pressure of three feet of water and at a rate of flow of three pints a minute. This is done from two to six times in twenty-four hours, about a gallon of fluid being used on each occasion.

As the chief function of irrigation is the mechanical one of removing pus and sloughs, the nature of the fluid used is almost immaterial, provided that it introduces no fresh organisms and contains no chemical irritant. Sterile water or saline is therefore used for the main cleansing, followed by a wash with 0·25 per cent HClO (eusol). In the case of large flesh wounds, or wounds which secrete a considerable quantity of viscid pus, a continuous flow of HClO through tube, wick, or drip, is maintained in the intervals, all wounds so far as possible remaining exposed to the air.

By the use of small sections of mattress for the uninjured leg, space is obtained to attach a tin shute to the splint. This carries off the fluid to a bucket beneath the bed. A very good water-tight joint between the shute, the skin, and the ring of a Thomas splint can be made with putty, as described by Major Sinclair. A simple formula for this is whitening and castor oil, into which is worked cotton-wool until the putty can be pulled out into a rope without breaking.

Little is gained by keeping any wound constantly wet for more than ten days. After this, periodic irrigation is continued daily with decreasing frequency, being regulated by the quantity of pus produced.

Hypertonic saline (2 to 5 per cent) has not proved so satisfactory for irrigation purposes as the fluids which produce free chlorine, and it is on these latter that reliance has chiefly been placed for the last twelve months. During the early part of 1915 a solution of chlorine in saline (Petrie) was employed. Later, trial was made of Dakin's hypochlorite solution, and of eusol (Lorrain Smith). The latter has been used most extensively, on account of the ease of preparation; but I am not satisfied that it is as efficient as Petrie's olution in the cleansing of wounds with anaerobic and streptococcal infection.

AMPUTATION.

Indications for Amputation.

1. *Shattered Knee.*—By this is meant comminution of both femoral condyles, or the upper extremity of the tibia, with an open septic joint.

2. *Sepsis.*—(*a*) Early: Subfascial anaerobic infection not limited to the immediate vicinity of the wound, shown clinically by rapid rise of pulse-rate with or without rise of temperature, rapid swelling of the thigh, hæmolytic jaundice, and the appearance of deep-seated gas. (*b*) Late: Streptococcal infections, with or without organisms in the blood-stream, where the patient goes downhill in spite of gravity drainage.

3. *Gangrene.*

4. *Secondary Hæmorrhage.*—In certain cases.

Technique of Amputation in Presence of Sepsis.—I have no hesitation in giving an unqualified condemnation of the flapless operation. Experience has not justified its necessity, and it has the disadvantage of submitting the patient to a further amputation, which may lead to recrudescence of sepsis with painful twitchings of the stump.

In the thigh, gravity and the position of the patient usually determine a higher level of œdema, and consequently less available skin, behind. A long anterior and short posterior flap, or an oblique oval incision coming down farthest in front, is therefore the most economical. As a rule, flaps of full length consisting of skin and subcutaneous tissues only are cut, a transverse section of muscles and bone is made, and the skin flaps are turned back on the thigh, each corner of the anterior flap being held in place by a single stitch.

The flaps may be cut through œdematous tissue, though if the latter is much discoloured some sloughing may occur. The inclusion of wounds in the flaps is always avoided if possible. The flaps are covered with a strip of sheet rubber an inch wider than the length of the main flap, and the whole wound is enveloped in a single sheet of gauze two layers thick. If gauze is placed in contact with the skin edges, its removal causes great pain. This sheet of gauze remains undisturbed for forty-eight hours, the dressing over it being changed as needed, and the surface of the stump irrigated through it.

The most suitable dressing for a stump depends on the condition for which amputation is performed. If for gas gangrene, a salt citrate dressing has given the best results, either wet in the form of gauze wrung out of a solution containing sodium chloride 5 per cent and sodium citrate 2 per cent (Wright), or dry in the form of a gauze pack containing tablets of sodium chloride and sodium citrate (Gray). After amputation for septicæmia or secondary hæmorrhage, the promotion of lymph lavage is not so essential; and as the salt citrate mixture may induce an undesirable flow of blood as well as the required outflow of lymph, I prefer a loose gauze pack wrung out of a chlorine solution. The tendency of the gauze to stick may be diminished by the addition of 25 per cent glycerin to the solution.

At the end of forty-eight hours the stump is completely uncovered, and the flaps are turned down and allowed to granulate.

Anæsthetic.—Spinal stovaine (1·5 c.c. of Barker's solution) is used, except in presence of œdema of the back. Ether may be necessary to secure a suitable position for spinal puncture where movement is very painful.

Subcutaneous infusion of saline is begun as a routine as soon as the patient is on the table. A tourniquet increases the liability of skin flaps to slough, and is therefore not used when their vitality is in danger.

After-treatment.—For the first forty-eight hours the face of the stump should look downwards, to secure gravity drainage. The customary pillow under it is therefore omitted, and the head of the bed raised as soon as the patient's condition allows. Mobility of the hip-joint is secured by occasional change of position of the stump. If the flaps are unduly short, an extension is applied when granulation is established, either by weight and pulley, or through the short Thomas splint suggested by Surgeon-General Sir G. H. Makins. Adhesion of the anterior flap to the end of the bone may be prevented by light massage.

Amputation through the fracture has no advantage over section of the bone at the most suitable level, there being no risk of osteomyelitis if the stump is treated as above described.

Partial suture of the flaps, with the introduction of tubes, does not give adequate drainage in the presence of active sepsis. The result is to cause local sloughing in the wound and bacterial invasion of the intermuscular planes of the stump, rarely of the bone. Such intermuscular infection is shown by persistent œdema of the stump, which retains a spurious appearance of health while the sound limb wastes. The condition usually results in abscess formation in the deeper parts of the stump, sometimes only after several weeks. The opening of such abscesses may be followed by dangerous recrudescence of septic absorption.

SEPTICÆMIA.

Out of the 34 septic cases referred to above, 6 developed the clinical picture of septicæmia, with swinging temperature, rapid pulse-rate, and gastro-intestinal disturbance.

In each of the six cases 10 c.c. of blood was examined by Capt. G. F. Petrie, and in five he found a streptococcus in pure culture, from twenty-one to thirty-five days after the infliction of the wound. The case of suspected septicæmia with a negative blood-culture was the only one which recovered without loss of the limb. In two of the five positive cases an attempt was made to save the limb; one of these died in France, the other in England after amputation at the hip-joint. In the other three cases the limb was removed, and all recovered. Two of the recoveries and one fatal case developed pyæmic abscess (in each case single), from which a streptococcus was obtained.

Treatment.—A trial was made of polyvalent antistreptococcus serum in two cases, 20 c.c. being injected subcutaneously every day—in one case for a week, in the other for three weeks. No appreciable effect was observed in either.

From a consideration of many other cases of septicæmia following compound fracture, I am convinced that the limb should be removed as soon as a streptococcus is found in the blood. In the absence of a positive bacteriological finding, or of pyæmic abscess, the clinical diagnosis of septicæmia is of doubtful value.

SECONDARY HÆMORRHAGE.

If the length of time elapsing between the receipt of a wound and the occurrence of secondary hæmorrhage is taken as a distinguishing feature, this serious accident appears in two distinct groups. The first comprises cases which bleed in the latter half of the first week and the first half of the second week; in the second group bleeding occurs in the fifth week. The proportion of early to late cases is 4 to 3.

While these two danger periods are so clearly separated by an interval lasting from the end of the second to the beginning of the fifth week as to be of definite value in prognosis, analysis shows that many of the late cases follow some slight operation for sepsis, such as the opening of a pocket of pus or the

removal of a sequestrum. Secondary hæmorrhage is liable to follow apparently minor operations of this kind at any period (up to at least three months), and after an interval of from four to ten days. That is, the majority of the late cases bear the same relation to an operation as the early ones do to the original wound; and the division of secondary hæmorrhage into such widely separate periods is really a consequence of one phase in the life-history of the septic process.

Predisposing Causes.

Local Sepsis.—The walls of the larger arteries can resist infection successfully so long as the wound is widely open, but a vessel of any size is liable to erosion in a wound whose drainage is insufficient.

General Sepsis.—Late secondary hæmorrhage occurs particularly in cases where the blood contains a streptococcus, and, as mentioned above, it usually follows a secondary operation.

Mechanical Injury.—The importance of drainage tubes as a cause has probably been overestimated, except in the case of a through-and-through rubber tube which is bent in the track so as to exercise constant elastic pressure at one point. Loose fragments of bone do not, in my experience, directly predispose to bleeding. Indirectly, they may do so through the medium of secondary operations for their removal.

Fatal hæmorrhage may occur entirely without warning, but a preliminary oozing is so common that its significance can never be disregarded.

Treatment.—The tourniquet or plug which has been used for the immediate checking of the bleeding is removed under anæsthesia as soon as possible, the wound is opened up freely, and the bleeding vessel clamped. If sloughing, the original wound is then dried out, packed with 10 per cent iodine for a few minutes, and excised to a depth of a quarter of an inch over the whole of that face of the wound which contained the bleeding point. Any sloughing tissue is trimmed off the rest of the wound at the same time. If the wound is not necessary for gravity drainage, it is packed with gauze saturated with eusol. Posterior wounds are packed round one or more drainage tubes which lead down to the fracture.

Should this procedure be followed by serious recurrence of the hæmorrhage, the main artery is tied at the nearest point above the wound where an aseptic operation can be performed, the incision for ligature being closed and isolated from the wound.

Repeated hæmorrhage occurring late in a case of known septicæmia is treated by amputation, irrespective of the quantity of blood lost. The repeated loss of a few ounces at a time frequently precedes a severe hæmorrhage, which may be fatal to a man who has had a swinging temperature and a pulse-rate of 120 for several weeks.

Hæmorrhage from an amputation stump is uncommon if the flaps are turned back and no tourniquet has been used. It is treated by local ligature, and, if repeated, by ligature of the main trunk at the nearest clean point. The material used for ligature of the main artery has no influence on the incidence of secondary hæmorrhage.

A STUDY OF THE SYMPTOMS AND COMPLICATIONS OF GUNSHOT WOUNDS OF THE SOLID ABDOMINAL VISCERA.

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Wounds of the solid abdominal viscera, although common, do not possess the inherent gravity incumbent on those of the alimentary canal. Uncomplicated type-wounds inflicted by bullets are indeed of little more importance than similar injuries involving the extremities of the body.

The diagnosis of these injuries is comparatively simple, since the range of movement allowed to the solid organs is so limited, that consideration of the course of the wound track, as indicated by the position and shape of the apertures of entry and exit respectively, affords fairly accurate evidence as to the implication of any particular viscus. Retained missiles are also readily localized by *x*-ray examination when they are situated in the solid viscera or their immediate neighbourhood.

Apart from the mere question of regional localization, certain pathognomonic symptoms and signs accompany wounds of each organ, although, as will be seen later, many instances occur in which these may be overlooked or be entirely absent. Again, definite signs are much more commonly detected in the injuries of the liver and kidney than in those of the spleen and pancreas.

Wounds inflicted by fragments of shells or of the various forms of bombs are, as a rule, more to be dreaded than those caused by the passage of a bullet. Such wounds are characterized by more extensive laceration, they are more irregular in nature, and more frequently multiple. The missile itself is more frequently retained, by reason both of the lesser degree of velocity with which it enters, and of its more irregular shape. Lastly, such missiles are, practically constantly, the carriers of infective material in a gross form.

WOUNDS OF THE LIVER.

Before proceeding to consider the symptoms, signs, and complications accompanying wounds of this organ, it should be premised that in many cases, especially of injury by bullets, no evidence of wound of the liver can be detected beyond that afforded by a consideration of the course taken by the missile, while in others such symptoms as are present are insignificant in degree. When other abdominal injuries exist concurrently, that of the liver may fall into quite a secondary position as far as danger to life is concerned. This is notably the case when a bullet cleanly traverses the organ without impinging on any large blood-vessel or bile-duct; fragments of shell of any considerable size and weight, usually produce injuries accompanied by well-marked symptoms.

The thirty-seven cases of wound of the liver dealt with in this communication in no sense represent the number of injuries of the organ met with during the period in which they were collected. They have been chosen on two grounds: (1) As forming a series in which the wound of the liver was obviously the chief element in the patient's injuries; and (2) As illustrating the varying degree of gravity which lesions of the organ may assume. Beyond this, the cases dealt with were all observed in base hospitals, and hence represent the conditions met with in patients who had already survived the initial injury for some days.

FIG. 243.—VERTICAL WOUND OF LIVER, WITH MISSILE *in situ*.

An eleven-days-old penetrating shell-wound of the liver. The point of entry was a large septic wound on the right anterior axillary fold. The thoracic wall was penetrated in the right fourth interspace in the mid-axillary line, with slight tearing of the intercostal muscles and of the parietal pleura, but with no rib damage. A large hæmothorax on the right side was found on the sixth day heavily infected with a streptococcus.

The missile has penetrated the right lobe of the liver, and is lying embedded in, and partly protruding from, the inferior surface of the organ. The centre of the wound track was filled with septic liquid material, heavily bile-stained. Outside this lies a zone of necrotic liver, the necrosis having supervened on infarction, followed by sepsis. This is separated from healthy liver by a well-developed strong capsule of inflammatory fibrous tissue.

Anatomical Character of the Wounds.—Two classes of wounds are met with: (1) Those of the nature of a rupture due to contusion; (2) Simple perforations of the substance of the organ, varying in size with the missile producing them. The mass of the liver offers considerable resistance; hence comminution on the one hand and retained bullets or fragments of shell on the other are comparatively common.

The most common *course of the wound-track* in the body is transverse. Thus, of thirty-six cases, in twenty-one the wound crossed the body transversely; ten of the transverse tracks crossed the body completely; four had an aperture of entry alone; in seven the course was antero-posterior; and in five the missile was retained. One track was very oblique from below upwards. In ten the track took a practically vertical course, ascending in eight, descending in two; in only one of the ten cases was the missile retained. In two cases the direction of the track was not recorded, and in one case the wounds were multiple.

With regard to the anatomical characters of the wounds of the organ itself, mere excoriations or simple furrows, while giving rise to the least tissue destruction, may be the source of more troublesome and persistent hæmorrhage than more serious-looking perforating wounds. Simple bullet tracks of the latter class are indeed the least severe form of damage, and account for

a large number of those cases in which no serious symptoms are observed. It is indeed remarkable, in examining such tracks post mortem, to observe how little the hepatic tissue bounding them has suffered from any lateral force exerted by the bullet.

Fragments of shell produce more extensive injuries. Thus, a groove may be a wide, ragged, gaping cavity, or the same characters may pertain in the case of a perforation of the organ. Injuries of this type are those which most frequently give rise to secondary hæmorrhage at the base hospitals. The wounds are almost invariably seriously infected from the outset, and after death they assume the form of wide gaping cavities or extensive broad tunnels lined with necrotic hepatic tissue, often stained a bright orange tint by bile pigment. When the tunnel does not traverse the whole thickness of the liver, the missile may be found at the distal end, often together with fragments of clothing.

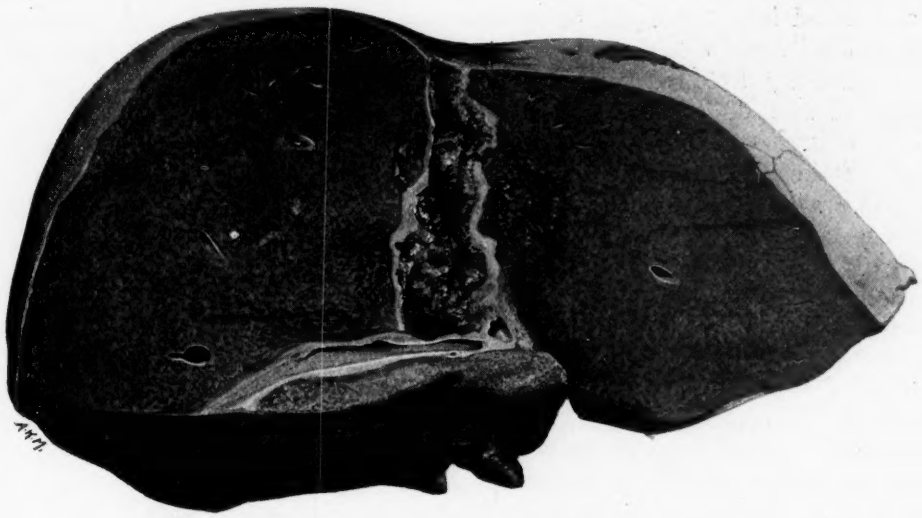

FIG. 244.—PENETRATING WOUND OF LIVER CAUSED BY A FRAGMENT OF SHELL.

Fig. 244 illustrates a moderate-sized wound track of this nature, of fifteen days' standing. The track is described by Captain H. Henry as being "filled with bright chrome-coloured septic material, the margins consisting of very ragged, necrosed, bright-yellow, liver tissue. Outside this is a dense, well-defined zone of fibrous tissue which separates the septic track from normal liver. Patches of infarcted liver which have not undergone necrosis, and are recovering, are visible on either side of the localized track."

This specimen, and that portrayed in *Fig.* 243, both prepared by Captain Henry, illustrate to some extent the remark made in the text as to the localized nature of the tissue destruction in perforations of the liver substance, even when produced by shell fragments. In both, however, the natural process of repair has reached a fairly advanced stage of development, and the velocity retained by the missile must be assumed to have been low.

When a large gaping septic wound becomes the seat of secondary hæmorrhage, and a localized collection of blood develops which needs to be incised, the evacuation of the infected blood-clot may be followed by progressive necrosis and sloughing of the liver. Large fragments of necrotic liver tissue may continue to be discharged for some time, and in this way a great part of the organ may be destroyed. This process is not unlike the rapid necrosis seen in some cases of acutely progressing tropical abscesses. An extensive, deep crater is then formed, with thickened, elevated margins. A similar condition may occur as a result of secondary suppuration, but is rarely so extensive.

While it is common for the more extensive injuries to be caused by fragments of shells, yet the type service-bullet, if it turns in its passage into or through the liver, may inflict almost equally severe damage. The tissue of the organ may be comminuted in great part, while from the most seriously damaged focus fissures similar to those seen in the contusions of civil practice may extend into the organ or radiate to the free margins. *Figs.* 245 and 250, pp. 654, and 658, show a similar condition in the kidney. Such injuries are commonly followed by a rapidly fatal termination from shock and the effects of loss of blood.

Concurrent Injuries.—The most common co-existent injury is involvement of the pleural cavity and lung. Thus, amongst thirty-seven cases, the pleural cavity was traversed in twenty-five instances; in two of these cases the external wound was sufficiently extensive to allow of prolapse of a portion of the liver; in two the lung was wounded and exposed; and in nine a more or less extensive hæmothorax was present, the latter, according to modern views, indicating that the lung was involved in the greater number.

Cases in which the hollow abdominal viscera have suffered concurrent injury occupy the place next in frequency; but such have practically been excluded from consideration in this paper, because in them the wound of the liver was usually only of secondary importance. In one of the instances included, a secondary perforation of the transverse colon (probably contused at the time of the original injury) developed in connection with a secondary hæmorrhage from the liver, and a part of the effused blood escaped into the bowel and was passed per anum.

The association of a wound of the right kidney is not rare; but in view of the good prognosis commonly attending renal injuries, this complication is not of great importance. In one instance of secondary subphrenic suppuration, however, the associated renal injury was an unfortunate factor in the development of a fatal issue.

Although concurrent injuries to the hollow viscera are for the most part excluded from consideration in this paper, the fact that determination of coexistent perforating injury to the stomach is especially difficult makes it worth while to quote a couple of illustrative cases.

Case 1.—(Under the care of Capt. Clementi Smith.)

A man was admitted on the fourth day after receiving a bullet wound which, entering in the epigastrium opposite the anterior end of the eighth right costal cartilage, traversed the trunk, and emerged in the left loin one inch below the junction of the middle and outer thirds of the twelfth rib. When examined, the patient

was suffering from great abdominal distention, with signs of peritonitis. He died shortly after admission, and at the autopsy made by Captain H. Henry the following condition was found. The margin of the right lobe of the liver was penetrated, and areas of infarctive necrosis were present around the apertures of entry and exit in that organ. There was no perforation of the stomach, but contusion of the lesser curvature at the pyloric end had given rise to hæmorrhage into the muscularis, while the subjacent mucous membrane was torn so as to give an appearance of an acute ragged ulceration. Two perforations of the jejunum, two and six inches respectively from its commencement, at the anti-mesenteric border of the bowel were found, also septic peritonitis, involving especially the left flank and the pelvis. In this instance the wound of the liver was of no practical importance, since it gave rise to no serious hæmorrhage, and the patient's death resulted from the jejunal injury. [*Ref. No.* 107.]

A second case of minimal injury to the liver, accompanied by serious hæmorrhage, both intraperitoneal and gastric, and by no other obvious lesion, may be quoted in contrast.

Case 2.—A man received a bullet wound entering the back of the shoulder. The bullet was retained. The patient arrived at the base on the fourth day with a diagnosis of pneumonia, and died shortly after removal from the train. At the autopsy made by Captain H. Henry, a small surface 'excoriation' of the liver was discovered, but no wound of any other viscus. The stomach, the duodenum, and the lesser sac of peritoneum were full of blood-clot, and death had resulted purely from hæmorrhage. [*Ref. No.* 108.]

Symptoms, Signs, and Complications of Wounds of the Liver.—As already stated, a gunshot wound of the liver may be accompanied by so little in the way of local signs or symptoms as to give rise to no practical discomfort to the patient. Thus, of seven out of the thirty-seven cases the clinical history of which is dealt with in this paper, no physical signs existed at the time of the patient's admission to the base hospital. In other cases the shock, pain, and distention accompanying any abdominal injury may subside, leaving nothing but some local tenderness, rigidity of the abdominal wall, and possibly some restriction of the respiratory excursions. In connection with the latter sign, the occasional occurrence of persistent hiccough should be mentioned. It was a troublesome feature in two out of thirty-seven cases, but as its causation depends on the association of the wound in the diaphragm, or on infection of the wound in the abdominal wall, it cannot be regarded as a sign of wound of the liver.

1. Hæmorrhage.—The most common result attendant on a wound of the liver is hæmorrhage into the peritoneal cavity, when the wound is extensive or the larger vessels are torn. This may rapidly lead to a fatal issue; and even if not of sufficient amount to cause death in itself, hæmorrhage from the liver is one of the most troublesome complications met with in dealing with associated lesions of the hollow viscera.

Cases in which abundant hæmorrhage has occurred are not often seen at the base hospitals; hence a diagnosis of injury to the liver founded on the classical signs of the presence of blood, either fluid or coagulated, in the right loin, is not often made. It should also be remembered that when the injury affects the under surface of the liver, the blood may collect in the lesser sac of the peritoneum and give rise to central signs; or when the anterior part of the organ is wounded, that the blood trickles freely over the surface of the

great omentum and eventually collects in the pelvis. Such collections may be infected and require to be evacuated.

Of vastly greater importance to the surgeon dealing with cases in a general hospital is the occurrence of secondary hæmorrhage. This accident occurs commonly at approximately the same date as it is met with in wounds of the kidneys or of the extremities of the body, that is, about the tenth day; but it may occur earlier, while in one of the included cases it was deferred to the twenty-third day. The occurrence of secondary hæmorrhage is always associated with septic infection, and it is a common cause of death from liver injuries. It was met with four times amongst the thirty-seven cases dealt with here, while amongst twenty-five autopsies made by Captain Henry on the subjects of wounds of the liver, secondary hæmorrhage was the direct cause of death in ten (40 per cent).

The advent of such hæmorrhage is commonly accompanied by pain, distention of the abdomen, rise of temperature, and acceleration and loss of volume in the pulse, associated with pallor, restlessness, and rapid loss of strength. With these general symptoms a localized swelling usually develops, if the patient survives the immediate loss of blood, and this may be indistinguishable from a secondary abscess.

2. Symptoms and Signs associated with the Biliary Function of the Liver.

i. *Jaundice.*—This symptom was noted as an early sign in twelve of the thirty-seven cases. It is therefore a common sign, but it is variable in degree. In some cases it is early and deep, in others slight and evanescent, and it is usually deepest when developing in association with serious septic infection.

The fæces retain their normal colour, and deep staining of the urine is rare. Again, in fatal cases no sign of gross mechanical biliary obstruction is met with. These features raise the question of the actual nature of the jaundice, as does also its close resemblance to the hæmolytic jaundice often accompanying the gravest forms of general toxæmia. It is, moreover, often associated with a considerable degree of fever. The sign is, of course, a classical one in the course of any case of rupture of the liver substance, whether due to gunshot injury or any other cause, and in all it is probably hæmolytic in origin. It is at any rate a striking fact that in the obvious absence of serious infection, jaundice is either very slight, or, as in the great majority of cases, it is not observed.

ii. *Biliary Fistula.*—The escape of bile by the wound is the most characteristic, and also a fairly common sign, of wound of the liver. The bile may either come directly to the external surface of the body, pass through the pleura, be expectorated from the lung, or collect in the abdominal cavity. Some form of biliary fistula was present in fifteen out of the thirty-seven cases under consideration. In seven of these the bile escaped from a wound in the abdominal wall. The length of time for which the flow persisted was only noted in three, the average duration being fifteen days. This period is, however, a long one, and it is far more common for the discharge to cease at the end of five or six days. Persistence depends mainly on the size, and degree of infection, of the wound.

In seven of the cases, the details in four of which were furnished me by Major T. R. Elliott, the fistula opened by way of the pleura. Four of these patients had an associated hæmothorax, and in only one did infection lead to the development of an empyema. All the patients got well, the case of empyema after resection of a rib, two of the cases after aspiration, and one as the result of a spontaneous discharge of bile. From one patient fifteen pints of bile were removed by repeated aspirations, the internal fistula finally closing about the fortieth day. The average date of persistence of the seven trans-pleural fistulæ was sixteen days.

Of the whole series of thirty-seven, only two patients expectorated bile; in one instance this ceased at the end of fourteen days, in the other it persisted for ten weeks. The latter patient, the subject of a shrapnel-ball wound which traversed both sides of the chest, had a left empyema not in connection with the liver wound, and also expectorated fragments of liver tissue, showing the wound of the liver to have been of a severe nature. This observation is of interest in connection with the analogous occurrence of the passage of fragments of renal tissue per urethram after comminuting gunshot wounds of the kidney.

With regard to the association of wounds of the liver and hæmothorax, it is of interest to record that in a total of 275 cases of chest wounds and consequent hæmothorax which survived, and of which notes were taken, Major Elliott met with only five examples in which a co-existent wound of the liver was clearly recognized by clinical symptoms and signs of the injury.

Again, among 100 consecutive autopsies made by Captain Henry on patients with chest wounds, in fourteen the liver was wounded: six of the latter died from hæmorrhage from the liver; in the remaining eight the hepatic injury in no way affected the fatal result.

In only one case in my own series did any considerable collection of bile take place in the peritoneal cavity, and in this instance a wound of the common hepatic duct, just proximal to its junction with the cystic duct, was present in addition to a traversing wound of the liver. This patient's abdomen was explored on the eighth day by Captain Wolfenden, and a collection of bile was found in the pelvis. The operation was undertaken in consequence of increasing local signs in the right hypochondrium. The patient died three days later of toxæmia. The right kidney had also suffered comminution.

As a rule, the presence of any collection of bile in the peritoneal cavity has not been a feature of fatal wounds of the liver. The liver substance bounding the track itself has been stained a bright yellow colour, but blood alone has been found in the peritoneal cavity.

I have seen no case at the base hospitals in which the gall-bladder has been perforated. Such injuries have been observed in the field ambulances and casualty clearing stations, and the statement has been made that the patients died from 'biliary peritonitis.' It appears doubtful whether fatal infection can follow the effusion of normal bile into the peritoneal cavity, and more probable that the peritonitis was caused by concurrent septic infection. My own limited experience of rupture of the gall-bladder in civil practice, amounting to only three cases, has been that, although the escape of bile led to considerable effusion of peritoneal fluid and a biliary ascites, no marked

inflammatory symptoms developed. Recovery followed in one case on simple incision and drainage, and in the two others on evacuation of the bile-stained fluid and fixation of a temporary drainage tube in the ruptured gall-bladder.

The evidence furnished by the six cases in which bile entered the pleura also seems in favour of the view that, apart from extraneous infection, the presence of free bile does not excite inflammatory reaction in a serous cavity. In only one of the six cases did an empyema develop, and that was an instance of an anaerobic infection lighting up after a latent period.

3. The Development of Secondary Suppuration.—With the existence of an open infected shell-wound, temporary suppuration is the rule, and not an occurrence of any great importance. The formation of secondary abscesses is a graver matter. Amongst the thirty-seven cases, four subphrenic and one anterior abscess were met with. The latter form is the less common, the anatomical conditions being such that the patients usually die from hæmorrhage or peritoneal infection; in the one case included, the man died from toxæmia.

Of the subphrenic abscesses, two developed between the anterior part of the upper surface of the liver and the diaphragm. In one case the abscess was in direct connection with a laceration of the liver caused by a fractured rib. The abscess developed subsequently to recovery from a right hæmothorax; it was incised and drained, and healed rapidly. In the second patient, the abscess resulted from the premature closure of a septic biliary fistula; this man also recovered after incision and drainage.

The third patient was admitted to the base hospital on the twelfth day after receiving a wound situated at the crest of the right ilium just behind the anterior superior spine. He had been retained twelve days at the casualty clearing station in consequence of the situation of the wound, and the fact that the missile was retained. On the thirteenth day the patient was in much distress, and signs of a subphrenic collection were evident. A portion of the eighth right rib was excised in the axillary line, and on incising the diaphragm a large quantity of bile-stained fluid with white coagula was evacuated. The patient was much relieved, but a week subsequently he developed left pleuro-pneumonia, and died on the twelfth day after the operation. No autopsy was made.

The fourth case also ended fatally, from toxæmia and lobar pneumonia. In this instance the back of the liver was directly damaged, and a laceration of the kidney was also present. The bullet had entered the chest wall in the posterior axillary line at the level of the right nipple, and emerged above the right great trochanter. The abscess was mainly lumbar in position; it was opened on the fifth day, and the patient died thirteen days later.

Causes of Death from Wounds of the Liver.—Examination of the post-mortem records of twenty-five cases in which wounds of the liver were a prominent feature, shows that 60 per cent died of some form of septic infection, and 40 per cent of secondary hæmorrhage. The figures are somewhat confused by the fact that concurrent injuries existed in seventeen out of the whole series of twenty-five patients. If eight cases in which the liver was the sole viscus implicated be separated, we find that four died from secondary hæmorrhage and four from septic infection.

The largest group is that in which the wound of the liver was complicated by a hæmothorax. Here we find seven cases of death from septic infection—two from acute anaerobic infection with gas formation, four from septicæmia (in two instances streptococcal), and one from simple toxæmia; five cases died from secondary hæmorrhage from the liver. It is evident that the latter deaths are those due solely to the hepatic injury, while the deaths from septicæmia were more probably in great part the result of the pleural infection.

In three cases involving the liver and kidney, one died of secondary hæmorrhage, one of an acute anaerobic infection, and one from pneumonia of the left lung twelve days after an abscess in the right loin accompanied by grave signs of general toxæmia, had been incised and drained.

Two cases in which the wound of the liver was associated with an intestinal injury both succumbed to peritoneal infection.

The numbers show clearly that the great majority, if not the entire number, of deaths from wounds of the liver occurring in the base hospitals are due to some form of septic infection. This statement does not appear to be weakened by the large number of deaths (40 per cent) ascribed directly to secondary hæmorrhage, since this accident is practically always the result of a septic condition of the wound. The post-mortem examination of all these cases was made by Captain H. Henry.

Prognosis and Treatment of Wounds of the Liver at the Base Hospitals.—At the period at which these injuries reach the base, that is, from the second or third day onwards, treatment is of a purely expectant character. Where a suppurating track is present and the missile retained, the latter may sometimes be readily struck by a probe and removed. In other instances, enlargement of the aperture of entry will allow the bullet or shell fragment to be reached. As a rule, planning a fresh incision to allow direct access to the retained missile is not to be recommended, as the fresh wound will be carried down into communication with a rigid septic tunnel. In rare cases the foreign body appears to become encapsuled, but in the only case observed by me during this war, too short a period had elapsed to allow it to be considered that the patient was safe from ulterior abscess formation. In none of the cases of secondary abscess which are dealt with in this paper was a foreign body discovered.

The method of selection of the particular series of cases dealt with in this paper renders it impracticable to deduce from them accurate evidence as to the relative gravity of injuries by bullets and fragments of shells respectively. The same circumstances prevent the drawing of any deduction as to the mortality attendant on wounds of the liver, for on the one hand the series deals with none of the injuries so severe as to lead to the death of the patient before he could reach a base hospital, while on the other hand few of the wounds of the liver giving rise to no serious clinical symptoms are included.

Such information can only become available, as also the proportion of cases in which serious symptoms develop, when it is possible to aggregate the results observed at the various stages of hospital treatment.

INJURIES TO THE SPLEEN AND PANCREAS.

These two organs may be grouped under one heading, because experience at the base hospitals has afforded little information regarding the effects or the gravity of the lesions.

Spleen.—That injuries to the spleen are sufficiently common must be assumed from the frequency with which wound tracks crossing the region occupied by this organ are met with. Again as in the case of the liver on the right side of the body, so on the left a wound of the spleen is not infrequently associated with a hæmothorax, the lesser frequency of the conjunction probably corresponding more or less exactly with the smaller sectional area occupied by the organ. The associated injury which comes next in frequency is concurrent wound of the left kidney. It seems indubitable that wounds of the spleen must complicate many perforations of the intestinal canal, also that they must be a common source of intraperitoneal hæmorrhage. In spite of these evidences of the frequency with which the organ is the subject of injury, yet a diagnosis of isolated injury to the spleen is rarely made on any grounds beyond the position of the external wounds and the direction taken by the internal track.

FIG. 245.—BULLET INJURY OF THE LEFT KIDNEY AND SPLEEN.

The upper pole of the kidney is almost separated from the lower two-thirds of the organ by a gross laceration. Numerous fissures pass downwards, involving nearly half the length of the organ.

A considerable portion of the upper and anterior part of the spleen has been comminuted, and less extensive fissures of the same nature as those seen in the kidney spread into the substance of the organ.

Such knowledge of wounds of the spleen as has been available at the base hospitals has been gained from the discovery of these lesions in operations or in post-mortem examinations on patients the subjects of other injuries. Thus, a wound of the spleen was discovered while performing an operation in a case of perforation of the splenic flexure of the colon; also, at three post-mortem examinations: (*a*) In a patient who died from spinal meningitis resulting from a wound of the spinal canal, and in whom the left kidney also was wounded; (*b*) In a patient with a wound of the transverse colon and a left hæmothorax, who died of septicæmia; and (*c*) In a patient in whom both kidneys were wounded, who died from secondary renal hæmorrhage.

In none of these four patients was the injury to the spleen the direct cause of death, and at the most it could only be regarded as a contributive element.

Fig. 245 illustrates a laceration of the spleen combined with a laceration of the left kidney. It will be observed that the character of this lesion does not materially differ from the corresponding injuries to the other solid viscera, except perhaps in so far as the softer and more granular nature of the splenic tissue affects the outline of the laceration.

Such evidence as can be gathered from clinical observation of a large number of wounds of the trunk over the area occupied by the spleen accompanied by no serious or diagnostic symptoms, seems to support the opinion already expressed by the writer,* that simple perforations and moderate lacerations of the spleen may heal spontaneously, and also that deaths from hæmorrhage following wounds of this viscus are not so common as might be expected.

Pancreas.—Injuries to the pancreas are just as difficult to detect, except by direct exposure of the organ, as are those of the spleen. Wounds of this organ have been discovered during the performance of operations for intestinal injuries, and the typical results of the escape of the pancreatic secretion into the tissues and peritoneal cavity have been observed. Such injuries have usually proved fatal.

Cases are, however, occasionally seen at the base hospitals in which a wound of the pancreas has either been survived for some days, or appeared probable in patients who have eventually recovered. The external wounds have in some of these instances been so situated as to suggest pancreatic injury; but the main difficulty in arriving at a certain diagnosis has lain in the possibility that the third part of the duodenum may have been the viscus actually involved.

This class of case is perhaps best illustrated by the relation of some instances.

Case 1.—(From No. 13 General Hospital. Under the care of Capt. Anthony Bradford.)

A man was admitted, wounded by a bullet which had entered below the left costal margin in the mid-axillary line, and which was retained. The patient arrived on the third day after the injury. He was in fair general condition, with a normal temperature and pulse-rate. During the next seven days he improved generally. Food was taken, the bowels acted regularly, and nothing abnormal was noted in the stools. There was no hæmaturia. The abdomen was flat and soft.

On the tenth day after the injury, pain in the side and nausea were complained of, the temperature rose to 100·4°, and the pulse became feeble and irregular; the man sank rapidly, and died on the eleventh day.

At the post-mortem examination a small ragged wound was discovered in the pancreas, much fat necrosis in the adjacent tissues and the mesentery, and a small quantity of pus was present in the neighbourhood of the injury. Beyond this, there was a wound of the left kidney and a little free blood in the peritoneum. [*Ref. No.* 109.]

Case 2.—(From No. 13 Stationary Hospital. Under the care of Lieut.-Col. Butler.)

A man was admitted on the tenth day after receiving a wound through the left rectus muscle immediately below the eighth costal cartilage. A fragment of shell was located by *x*-ray examination, lying in front of the lower and left part of the body of the third lumbar vertebra. The patient had walked six miles after receiving

**Surgical Experiences in South Africa*, 1899–1900. Second edition, p. 482.

the wound, and had suffered no abdominal pain; he did not vomit. He had evidently been retained at the casualty clearing station on the suspicion of an injury to the alimentary canal.

When received from the train, the patient was in fair general condition, his temperature was 99°, and the tongue furred and rather dry. A large fluctuating swelling was present in the epigastrium.

On the following day the abscess was incised by Lieut.-Col. Butler, and a large quantity of pus of a dull slate colour evacuated. The pus was not foul. The intraperitoneal cavity was well bounded, and in its depth a soft, velvety-feeling substance was suspected to be the injured pancreas.

During the next week the wound contracted rapidly and the pus decreased steadily in amount, although both anaerobes and streptococci were cultivated from it.

At the end of three weeks the patient was sent to England in good condition, with only a small sinus persisting. In the early days the margins of the incision were red, and the appearance suggested some digestive change, but there was no digestion of the surrounding skin. [*Ref. No.* 110.]

Case 3.—(Under the care of Lieut.-Col. Butler.)

In this instance the wound was in the back, and both the discharge and the appearance of the wound and surrounding skin suggested the escape of digestive secretion. This wound closed spontaneously and rapidly.

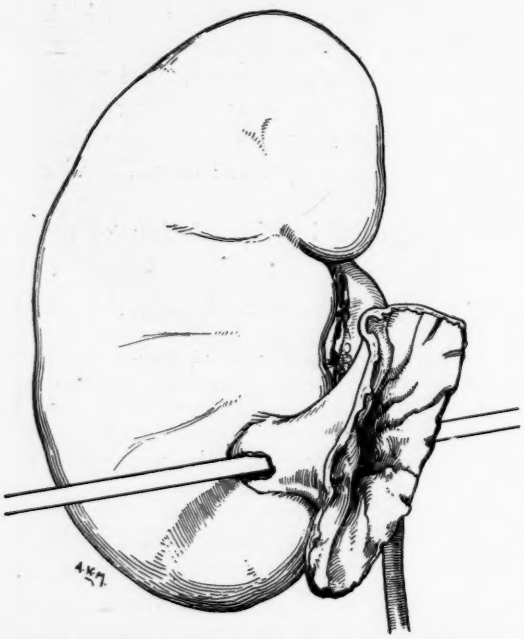

Fig. 246.—Minimal Injury to the Right Kidney accompanying a Retroperitoneal Perforation of the Duodenum.—A second exactly similar injury was also met with. In neither case was any sign of the renal lesion observed, and in both the injured duodenum contracted adhesions to the groove in the kidney.

In neither of the last two cases did the pathologist succeed in demonstrating the presence of pancreatic ferments; but in both, the amount of discharge was moderate, and mainly purulent.

INJURIES TO THE KIDNEYS.

Simple perforations of the kidney by rifle bullets may often be regarded as almost negligible injuries; exceptions to this statement, however, are not very rare, the most common source of danger being, as in so many other classes of gunshot wound, the occurrence of secondary hæmorrhage.

The small series of injuries dealt with in this paper belong to the severer class, and afford no material for the formation of an estimate of the general mortality attendant on gunshot wounds of the kidney. They are selected as being those in which the renal lesion takes the most prominent place, but at the same time they have been chosen with regard to the co-existence of the complications most frequently associated with injuries to the organ.

Among the twenty-seven cases included, twelve of the injuries were

inflicted by bullets, two of these being retained; and ten were caused by fragments of shell, seven of which were retained.

In twenty-one the wound, either of entry or exit, was situated in the loin. In one case the track crossed the trunk transversely, in one vertically, in one obliquely from the epigastrium to the left flank, and in four it traversed the lumbar region in an antero-posterior direction. In several of the cases the wound in the loin was large.

The anatomical characters of the lesions of the kidney itself are sufficiently illustrated by reference to *Figs.* 245, 246, 247, 248, 249, 250. It will be seen that

FIG. 247.—BULLET WOUND OF THE KIDNEY.

The small aperture of entry is seen in the inset. The larger exit wound at the opposite surface exhibits well the protrusion of the renal tissue and a moderate degree of destruction. The lacerated capsule has receded some distance on the surface of the organ.

FIG. 248.—OBLIQUE PERFORATION OF THE KIDNEY CAUSED BY A BULLET.

The glass rod projects from the exit aperture. The relation of the track to the hilus of the organ is of importance with regard to the secondary hæmaturia.

the organ may be simply grooved, perforated, more or less completely bisected, or actually comminuted in a great part or nearly the whole of its extent. In connection with actual comminution of a part of the kidney, fissures may extend into the remaining segment of the organ. The wound of the kidney is accompanied by hæmorrhage into the perirenal tissue, often very abundant, and a variable amount of urinary extravasation, not as a rule extensive.

Excluding co-existent injury to the hollow viscera, the most common complications of wounds of the kidney are naturally wounds of the liver, the spleen, and the pleuræ. Wounds of both kidneys are occasionally met with,

and injury to one or both kidneys may complicate wounds of the lumbar portion of the spine.

Signs and Symptoms of Injury to the Kidney.—In a considerable proportion of the simpler injuries, the position of the apertures of entry and exit of the missile, indicating the course of the wound track, may form the only evidence of wound of the kidney; in others transient hæmaturia occurs.

Hæmaturia.—This cardinal primary symptom is often absent, or, being transient, it passes unobserved under the conditions of war. Still, putting aside the obvious source of fallacy from the second condition, primary hæma-

FIG. 249.—BULLET WOUND OF THE RIGHT KIDNEY.

This has practically bisected the organ, extending into the renal pelvis. Hæmaturia was a marked feature of the symptoms.

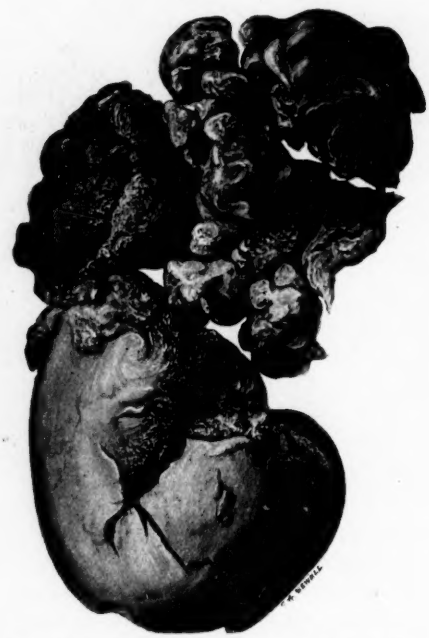

FIG. 250.—COMMINUTION OF THE UPPER HALF OF THE KIDNEY.

The organ has been reconstructed by assembling a number of fragments enclosed in blood-clot.

turia is rarely profuse and persistent. Of the twenty-seven cases dealt with here, a history of primary hæmaturia was only obtained in eleven, and was severe and persistent in but one. In this latter patient the hæmorrhage continued for seven days, and after one day's intermission it recurred in the form of a secondary hæmorrhage, eventually demanding a nephrectomy.

The degree of hæmaturia may no doubt depend in some measure on the nature of the renal lesion, but it by no means necessarily accords with the severity of the damage. Thus, in *Case* 1 (*Fig.* 250) described below, no history of primary hæmaturia was obtained. In this instance the question arose

whether the absence of primary bleeding was not to be explained by the fact that the ureter was mechanically obstructed.

Case 1.—(Under the care of Capt. Clementi Smith.)

The patient had been wounded by a bullet which had entered over the sixth left rib in the nipple line and emerged by a large 'explosive' opening over the third lumbar spinous process. No hæmothorax developed, and no primary hæmaturia was noticed. A few days later the patient arrived at Boulogne, with the wound suppurating.

On the twelfth day secondary hæmorrhage from the wound took place, and a large swelling developed in the left lumbar region. On the thirteenth day the man was wandering, the pulse was rapid and weak, the urine 'dark,' and blood flowed freely from the wound in the loin. A type lumbar nephrectomy incision was made, the hæmatoma evacuated, and the kidney rapidly enucleated. The hæmatoma extended high up beneath the diaphragm, and the quadratus lumborum was much lacerated.

The patient bore the operation well. No hæmaturia followed the nephrectomy, but on the third day the patient had an attack of renal colic, and later passed from the bladder a fragment of kidney large enough to have completely obstructed the ureter. A slow and uneventful recovery followed.

The passage in the urine of fragments of renal tissue together with blood is a rare but also a special feature of gunshot wounds of the kidney.

Case 2.—(Under the care of Capt. Buxton.)

A man was wounded by a bullet which entered just below the right costal margin in the nipple line, and emerged below the twelfth rib behind. Primary hæmaturia followed, and continued, except for one day's interval, until the patient's arrival at the General Hospital on the eighth day. Some dysuria from the presence of blood-clot in the bladder had necessitated occasional catheterization.

On the ninth day the patient's general condition was good; he looked sallow, but the pulse was of fair strength and not rapid. The hæmaturia and dysuria persisted, and on this and the following day ninety ounces of urine and blood were voided, the urine containing streptococci.

On the twelfth day, as no improvement had taken place, a type right lumbar nephrectomy was performed. The perirenal tissues were infiltrated with blood and some urine, but no extensive extravasation of urine had occurred. The bladder was full of blood-clot, which was removed with a lithotrity evacuator. The kidney was practically bisected, and was large, probably partly as a result of infection (*Fig.* 249).

For the next three days seven pints of urine were voided daily, the quantity then decreasing until the normal was reached on the seventh day.

The patient meanwhile was ill from the streptococcic infection, and made a very slow recovery.

There seems some reason to assume that blockage of the ureter by the fragment of kidney may have prevented the passage of blood by the ureter in *Case* 1, while in *Case* 2 the nature of the wound, extending into the middle of the pelvis of the kidney, and involving large blood-vessels, explains readily the amount of the hæmaturia.

Case 2, however, bears indirectly upon another question—whether the severe damage of the kidney has not the effect of causing a cessation of the secretion of urine by the damaged organ, and hence of decreasing the likelihood of the passage of blood along the ureter. Circumstances do not allow of a regular record of the amount of urine passed by such patients being kept, so that I cannot advance evidence of this kind, but the polyuria of ninety

ounces, even before the nephrectomy, does suggest that the right kidney may have been placed *hors de combat.* I am much inclined to think that a temporary cessation of secretion may be an element in the absence of hæmaturia in the injuries, and an effort is now being made to clear up this question at the casualty clearing stations.*

Primary hæmaturia, when persistent, is very liable to give rise to trouble some dysuria, and sometimes to retention, from coagulation of the blood and distention of the bladder by clot. This has occurred in several cases, and in two necessitated the performance of a cystostomy for the relief of symptoms. Mention will be made again of this complication under the heading of treatment.

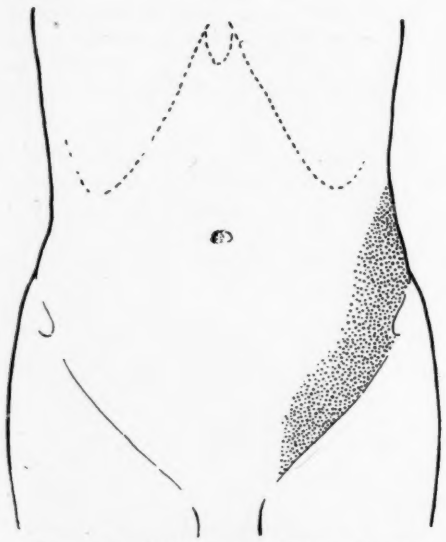

FIG. 251.—Diagram illustrating the common course of extension of a peri-renal hæmatoma, and the gravitation ecchymosis sometimes observed.

Secondary hæmorrhage was a symptom in twelve of the twenty-six cases under consideration. The date of its occurrence varied from the sixth to the twenty-third day. In every instance the urine was infected with either streptococci or *Bacillus coli*, and in a large proportion of them as a sequence of catheterization.

The hæmorrhage took the form of persisting hæmaturia in twelve cases, and in seven a large peri-renal hæmatoma developed. The extension of the hæmatoma was commonly in a downward direction, and, as a rule, the blood travelled freely into the loin and iliac fossa, then following the line of Poupart's ligament (*Fig.* 251). In one instance the retroperitoneal hæmorrhage attendant on fragmentation of the right kidney extended into both the epigastric and umbilical regions. In another, a localized hæmatoma developed on the anterior surface of the left kidney, in spite of the fact that the kidney itself formed the floor of a large 'explosive' exit wound in the loin from which external secondary hæmorrhage was taking place. The oval swelling presenting beneath the left costal margin closely simulated a typical left uronephrosis (*Fig.* 252).

The retroperitoneal blood extravasation is in many cases accompanied by the development of gravitation ecchymosis of the overlying skin, the discoloration corresponding more or less exactly with the area occupied by the subjacent blood (*Fig.* 251). The development of the hæmatoma is usually accompanied by considerable elevation of the body temperature, which is not

* Since this paper was written, some observations made by Captain Adrian Stokes, and quoted by Sir Anthony Bowlby in his Bradshaw Lecture, afford suggestive evidence of the immediate effect of severe concussion of the kidney on its secreting tissue (BRITISH JOURNAL OF SURGERY, Jan., 1916, p. 460.)

to be regarded as evidence of suppuration. In the absence of serious infection such hæmorrhages may clear up entirely without surgical intervention.

Of the twelve cases in which severe secondary hæmorrhage occurred, there was a history of primary hæmorrhage in four; in four no history of primary bleeding could be obtained; and in four the information was not sought for, or at any rate not noted at the time.

Intraperitoneal hæmorrhage is often associated with gunshot wounds of the kidney; but cases in which this occurrence can be certainly determined are not commonly met with at the date at which the patients reach the general hospitals. The presence of considerable intraperitoneal hæmorrhage was assumed in three of the twenty-six cases here dealt with.

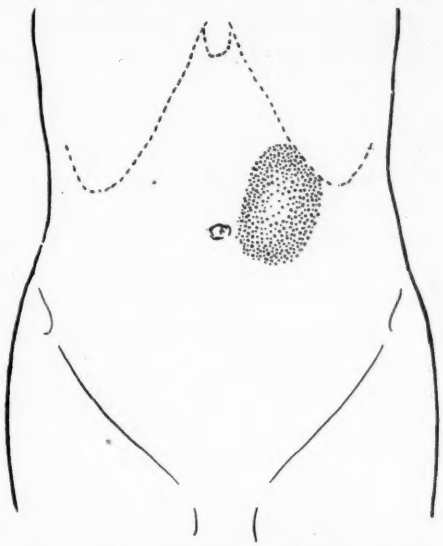

FIG. 252.—Diagram illustrating the position of an anterior peri-renal hæmatoma in connection with a wound of the left kidney.

Extravasation of urine is usually not a prominent feature. In cases in which a nephrectomy becomes necessary, the tissues are as a rule infiltrated with blood, and with only sufficient urine to allow of its presence being determined. The fact that perinephric abscess is an uncommon sequela is significant of the absence of any serious amount of urine in the tissues, considering the frequency with which secondary hæmorrhage, dependent on infection, occurs. Here again, support is given to the view that the recently wounded kidney does not secrete actively. It is further noteworthy that when the wound in the abdominal parietes is large, and urine escapes externally, the flow of urine during the first twenty-four to thirty-six hours is not abundant. In several cases it has been first noted on the patient's arrival at a base hospital. Occasionally the flow of urine occurs through the pleura; in one such case observed by me the patient made a good recovery. External escape of urine was noted in seven out of the series of cases under review.

The escape of urine is naturally most likely to be abundant when the pelvis of the kidney is involved in the wound. In one such case, a patient with a normal bullet entry wound over the ascending colon, and a large 'explosive' exit wound in the right loin, was sent down to the base on the third day on the assumption that no visceral wound existed. No hæmaturia had been observed, and no escape of urine from the wound. On the night of the patient's arrival urine was evidently present in the dressings, and for the next two days appeared to flow freely from the wound. A widespread urinary extravasation extending across the back then developed, necessitating several free incisions. The wounds healed rapidly later, and no doubt the opening in the renal pelvis closed as it usually does after a renal exploration

Complications and Causes of Death.—The most common direct cause of death from gunshot wound of the kidney is secondary hæmorrhage. Thus, of sixteen fatal cases, this accident, associated with varying degrees of toxæmia, accounted for the fatal issue in seven.

Four patients succumbed to gaseous cellulitis of the retroperitoneal tissue as a result of anaerobic infection.

The remaining five patients died as a result of associated injuries: thus, one succumbed to meningitis due to a wound of the spine; one to toxæmia due to a co-existing wound of the duodenum (*Fig.* 246); one to toxæmia, a wound of the liver also being present; one to left pneumonia following a right subphrenic abscess, the liver being also wounded; and one to gangrene of the stomach, the bullet having divided the vessels in the gastro-splenic omentum.

As to the associated lesions met with in the whole sixteen fatal cases: the liver was wounded in six, the spleen in two, a hæmothorax was present in three, a wound of the spine in one. It is obvious that the most common associated injury of all is a co-existing wound of some part of the intestine; but as the latter is so much the more serious lesion, no such cases have been included here beyond the two mentioned above involving the gastro-splenic omentum and duodenum respectively.

Prognosis and Treatment.—Uncomplicated wounds of the kidney, either by bullets or fragments of shells, cannot be regarded as serious injuries, apart from the danger of secondary hæmorrhage. The treatment of the slighter injuries consists solely in rest to the patient, and, if there should be severe primary hæmorrhage, the administration of opium.

It is rare for the primary hæmorrhage to be sufficiently copious and persistent to demand operative interference, and as has been already pointed out, urinary extravasation is seldom a cause of trouble. Should the former condition exist, in the absence of serious infection the hæmorrhage may be controlled by suture of the renal wound or removal of the damaged segment of the kidney. If the kidney is hopelessly damaged it must be removed.

The treatment of secondary hæmorrhage is not so simple. It can hardly be considered safe to try the effect of suture of the wound, in view of the fact that the secondary bleeding is without exception the result of infection of the kidney. Hence, a nephrectomy is the proper treatment.

The formation of blood-clot in the bladder may lead to considerable dysuria; it is inadvisable under these circumstances to pass a catheter unless absolutely necessary and until the effect of alkalies and hyoscyamus has been tried, on account of the dangers of infection of the bladder and possible spread of this to the kidney. Actual complete retention from the formation of a large solid blood-clot should be treated by breaking up the clot and removing it by means of a lithotrity evacuator. The occurrence of the latter complication is rare except in cases which demand at the same time a local operation on the kidney for the control of hæmorrhage.

If a urinary fistula is present in the loin, it is sometimes necessary to enlarge the wound in the loin in order to ensure a free exit and prevent urinary extravasation. This eventuality is rare, unless the wound track is long and narrow or very oblique in direction.

Local operations on the kidney in the early stages may consist merely in the evacuation of a peri-renal hæmatoma, or in direct treatment of the renal wound. In either case, hæmorrhage is practically the sole indication. Reference to *Figs.* 245–250 will suffice to fully illustrate the conditions that may need to be dealt with, since every degree of injury is included.

It is obvious from the figures that many injuries occur suitable to local operations such as suture, packing, or partial removal of the organ. In fact, however, the rarity with which primary operative measures are called for has not afforded great scope for these methods. With the growth of the principle of early abdominal exploration they may be more frequently applied, since the difficulty in making an accurate diagnosis in intra-abdominal gunshot lesions in the initial stages of their course, has led to the exposure and treatment of many gunshot wounds of the liver, kidneys, and spleen which might not have demanded actual surgical intervention had their nature been otherwise demonstrable. This remark applies especially to lesions of the solid viscera accompanied by abundant intraperitoneal effusion of blood.

My experience has been limited mainly to the treatment of the secondary results of these injuries, and the indication for operation has in every instance been secondary hæmorrhage following infection of the kidney itself or of blood extravasated in the retroperitoneal tissue. In none of these cases was a limited operation justifiable, although, as may be seen by the illustrations, the actual lesion was hopeless in one instance only. This opinion is founded on the fact that a partial operation is not likely to remove the primary cause of the bleeding, viz., infection. Hence it is not right to expose a patient already grossly anæmic to the risk of a fresh hæmorrhage from a sutured or partially resected organ. Experience of the treatment of cases of secondary hæmorrhage following nephrolithotomies on septic kidneys occurring in civil practice, seems to fully support this opinion.

As to the operation of nephrectomy for gunshot wounds, little requires to be said. The main characteristics are the occasionally very great comminution of the organ into many fragments, the want of solidity which results from extensive fissuring, the amount of blood extravasation into the retroperitoneal tissue often present, and, when the operation is performed after the first few days, the difficulty of enucleating the organ by reason of the stiffness and rigidity of the surrounding tissues.

The latter difficulty deserves some mention. It appears to depend on the reaction of the tissues to the presence of extravasated blood, rather than the infiltration of the parts with urine. That this is the case appears to me to be supported by the fact that an exactly analogous condition is met with in the tissues around a wounded blood-vessel in the limbs, that any collection of urine around the kidney is rare, and that secondary suppuration around the kidney is also rare. I have met with but one instance of a localized urinary abscess following a gunshot injury of the kidney.

The one troublesome complication met with after nephrectomy has been the formation of blood-clot in the bladder. Two cases where this occurred, in the absence of lithotrity evacuating tubes required to be dealt with by suprapubic cystotomy. In a third case, an evacuating tube

was fortunately at hand. One moral is abundantly evident from this experience. No patient should be allowed to leave the operating table until the surgeon has satisfied himself that the bladder is empty and contains no blood-clot.

Of eight nephrectomies, six recovered. The two patients who died were the subjects of very severe injury and widespread hæmorrhage; both were in bad condition, from the point of view of septic infection and anæmia, at the time the operation was performed. In one of the patients included in the series, a primary operation was followed by a temporary fistula of the ascending colon, which closed spontaneously after a few days. It may be broadly stated that removal of the kidney for hæmorrhage following a gunshot injury is a successful operation in suitable cases.

In conclusion, I must not omit to express my indebtedness to Captain H. Henry, who made the post-mortem examinations in all the cases of injury to the liver referred to in this paper. The renal specimens which form the subjects of the illustrations were, with one exception, procured as the result of operations. I am indebted also to Major Elliott for information regarding the association of wounds of the liver with tracks crossing the chest; and to my A.D.C., Lieutenant L. W. Shelley, for help in keeping and arranging the records of the cases dealt with.

A NOTE ON GUNSHOT WOUNDS OF THE SOLID ABDOMINAL VISCERA, AS SEEN AT THE FRONT.

By Colonel CUTHBERT WALLACE, A.M.S.
Consulting Surgeon to the British Expeditionary Force.

The number of wounds of solid organs that the surgeon is called upon to treat is not large. In a series of 366 abdominal injuries, the liver was wounded 69 times, the kidney 13, the spleen 11, and the pancreas 1.

The Liver.—The wounds of this organ present all degrees of trauma, from a small simple perforation or a superficial tear to an almost complete disruption. The symptoms are almost entirely those of hæmorrhage, and the concomitant shock, when present, is for the most part due to the same cause. Many injuries get well without operation; and many that are submitted to this treatment, with a view to the exclusion of intestinal injury, would no doubt follow the same course. The amount of hæmorrhage depends in some degree on the extent of the laceration, but to a greater extent on the rupture or escape of the large venous channels. Thus, a large tear may be, and often is, recovered from, while a comparatively small wound may rapidly prove fatal from copious bleeding from one of the non-collapsible veins. It is the latter class of case in which operation is really instrumental in saving life. Plugging with gauze is the best way to arrest the hæmorrhage. The plugging is withdrawn day by day, the time of removal being governed by the nature of the injury: in the case of a ruptured vein, the gauze must be left *in situ* for

several days; in the case of surface oozing, its removal may be commenced within twenty-four hours.

Injury of the large bile-ducts is not frequent. In the few cases where it has been met with, it has been treated with a drainage tube and a gauze plug. No actual wound of the gall-bladder was seen in the cases quoted above.

In a few instances the blood in the abdomen has been mixed freely with bile, and its presence has apparently led to an increased rigidity of the abdominal wall, though no case of a genuine biliary peritonitis has been met with. Bile has also been known to find its way into the pleural cavity, and has been evacuated through the ordinary empyema opening.

Jaundice has been met with in a few cases. It is seldom more than a passing manifestation, and is usually of no great intensity. It is not accompanied by fever in the casualty clearing stations. Whether it is due to blocking of the small ducts or to a septic infection is still undecided. The urine may contain bile pigment.

The Kidney.—The kidney may be wounded by itself, but almost as frequently in conjunction with other organs, such as the liver, spleen, stomach, colon, or duodenum. Many wounds are insignificant in themselves, and are often but slight complications of other more serious lesions.

The symptoms, as in civil practice, are those of hæmaturia and hæmorrhage. The latter is more often intraperitoneal than is the case in contusion injuries which form the greater part of the cases seen in ordinary hospital work. The frequency with which hæmaturia is present cannot be stated, as many of the more serious cases are rapidly submitted to operation on account of dangerous hæmorrhage. It is therefore impossible to tell whether the kidney ceases to secrete urine, though from the apparent absence of urine in the belly this is probably the case.

The only indication for treatment is hæmorrhage into the abdominal cavity, and it is in the course of an exploratory cœliotomy for such a condition that the organ is found injured. The nature of the trauma is anything from a simple tear or perforation to a complete division or total disruption. There is usually a marked absence of urinary extravasation when the kidney substance is involved in the injury; but should the injury to the body of the organ be slight and the pelvis also injured, the blood effused may be mixed with urine.

If the injury is severe, removal of the organ is the safest plan. This is especially the case where the spleen is also extensively lacerated, and much blood lost, for time here is an important factor, and an attempt to save a portion of the kidney and arrest the hæmorrhage by suture may not only considerably lengthen the operation, but may be followed by a continuance of the bleeding before its final arrest.

The Spleen.—As in the case of the kidney, the injuries vary from a simple tear, perforation, or abrasion to a complete disruption.

The organ most often injured in conjunction is the kidney, and next to this the colon, though the total cases collected up to date are too few for a positive statement.

Next to the liver, the spleen is, among the solid organs, the one most often injured by itself. From its close apposition to the stomach, one would

expect injuries of the two viscera to be frequently associated. As a matter of fact it seems but rarely that the two organs are discovered to be wounded together, and this fact suggests that such cases are rapidly fatal and never reach the surgeon.

There are no special symptoms that can be said to be associated with this injury. Intra-abdominal hæmorrhage, with perhaps a dullness of the left flank and hypochondriac region, are the conditions that usually call for surgical interference. A wound in the splenic region may suggest the possibility of an actual lesion of the spleen.

The nature of the injuries suggests that many patients get well by themselves. One case may be quoted, in which a bullet had passed over the splenic region in an antero-posterior direction, dividing the ribs in its flight. The surface of the spleen was furrowed by the bullet, while radiating splits in the capsule ran out from above the bullet track. This latter was oozing freely, but the radiating tears had ceased to bleed. The worst places were sutured, but from the appearance of things it is probable that complete recovery would have taken place without any surgical aid.

When the hilum of the organ is entrenched upon, the bleeding is apt to be profuse, and removal is the best course. The organ is difficult to reach by any vertical incision, and it is nearly always necessary to use a transverse extension or an incision parallel to the ribs.

The Pancreas.—Very few of these injuries come under the notice of the surgeon. The two cases seen were met with in the course of an abdominal exploration, in which the missile, passing laterally, had ploughed up the posterior abdominal wall and produced much extravasation of blood. There was fat necrosis to a slight extent, scattered about the abdomen. Both cases were rapidly fatal. In a third case, an antero-posterior bullet had passed apparently through the pancreas and escaped from the body without doing further injury; this man was sent to the base in good condition.

NOTES ON A SERIES OF SEVENTY-FIVE CASES OF GUNSHOT WOUNDS OF THE CHEST.

By Captain J. L. MENZIES, R.A.M.C.

One of the most striking features of a modern military hospital is the large number of cases of penetrating gunshot wounds of the chest admitted with comparatively trivial symptoms. The immediate results following such injuries are often marked and severe, but those patients who survive and are sent to a base hospital are often surprisingly well when first admitted. The experience of military surgeons in the present campaign serves to confirm the observations made in the South African War, that the modern high-velocity, hard-jacketed rifle bullet can pass through almost any part of the lung, and sometimes probably through the heart, without death of the patient resulting.

It is impossible to calculate with any degree of accuracy how many cases of gunshot wounds of the chest die on the field of battle from injury to the heart or large vessels, but it would seem that even extensive wounds of the lung and the chest wall may be recovered from. The actual site of penetration of the chest is undoubtedly of importance on the field of battle, as many with injuries to the root of the lungs and large vessels, die soon after injury; but in those who recover sufficiently to be removed to a base hospital, injuries are met with in every conceivable portion of the chest, and recovery is little affected by the site of the wound.

A very noticeable feature in a series of cases of gunshot wounds of the chest is the rapid recovery where there is no destruction of the chest wall, compared with the high mortality in cases with an open wound on arrival at the base. Cases where a wound in the chest opened into the pleural cavity, with communication between that cavity and the outer air, were almost uniformly fatal.

At the 21st General Hospital at Ras-el-Tin, Alexandria, 75 cases of gunshot wounds of the chest were admitted between July 1 and Sept. 31, 1915. By the courtesy of Captains Blacker, Wareham, and Whittaker, in charge of surgical wards, I had the opportunity of examining all these cases. This hospital serves as one of the large base hospitals for operations in Gallipoli. Cases are brought by hospital ship from the Peninsula to Alexandria, and the average time in this series of cases between injury and admission to hospital was five to six days, most of which time was spent on a well-equipped hospital ship.

When the chest wall and the contained viscera are penetrated by a projectile, certain marked symptoms present themselves. These symptoms, in their order of frequency, are pain, shock, dyspnœa, and hæmoptysis, all of

which occur at the time of the injury or soon after. They are referable in the first place to damage to lung tissue, and secondly to the resulting escape of blood or air into the pleural cavity, caused by damage to lung or blood-vessels.

Pain is present to a greater or less degree in all cases. It is rarely very severe, and calls for little comment.

Shock may be severe, at times resulting in collapse and loss of consciousness. A few cases were able to walk after receiving a penetrating wound of the chest, but these were exceptional.

Dyspnœa is almost always present at the time of the injury, and is generally characteristic. The distress in breathing in most cases is so great that the patient appears to be choking, and is continually fighting for breath. It is most noticeable in cases where there is a large sudden effusion of blood or escape of air into the pleural cavity. In most cases the dyspnœa improves after twelve to twenty-four hours, when the lungs become accustomed to the unusual conditions. Where effusion of blood in the pleural cavity is increas-

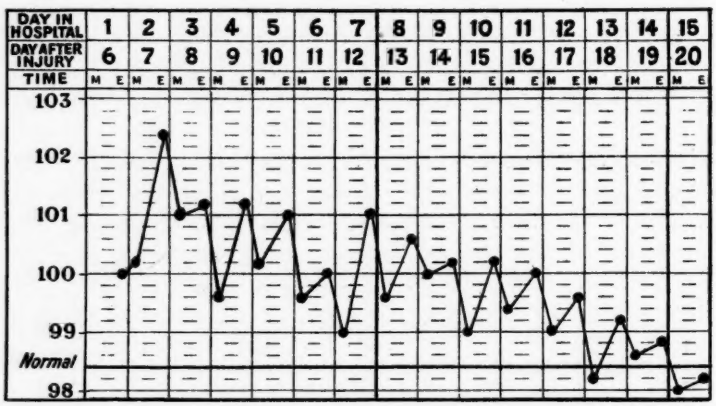
DAY IN HOSPITAL
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
DAY AFTER INJURY
6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
TIME
M E M E M E M E M E M E M E M E M E M E M E M E M E M E M E M E
103
102
101
100
99
Normal
98

FIG. 253.—TEMPERATURE CHART IN A CASE OF STERILE HÆMOTHORAX.

ing, the dyspnœa generally increases proportionately. Among 75 cases, only 12 gave no history of dyspnœa.

Hæmoptysis occurs in the majority of cases. It occurs either immediately after the injury, or after a delay of some hours. It is seldom very severe, and generally lasts two to three days, but there may be clots for a week or more. Of the 75 cases, 27 had no hæmoptysis at any time; in 40 cases it came on immediately after injury; in 8 it was delayed from one to twelve hours. The actual amount of blood coughed up is difficult to estimate under the best circumstances, and the various estimates of patients are certainly very erroneous. The amount varies from 'clots' to a pint.

The temperature is said to be elevated in all cases after chest injury.

On admission to the base hospital, the earlier symptoms have disappeared, and the symptoms which are now present depend on the existing condition—whether there is effusion or not, and whether the effusion is septic or sterile. The most prominent symptoms are dyspnœa and pyrexia. Most cases show signs of effusion of blood into the pleural cavity, and a minority signs of blood

and air. Bronchitis is present in nearly all cases. Surgical emphysema of the chest wall occurs in a few.

The dyspnœa is generally proportionate to the amount of effusion and consequent displacement of the mediastinum. Occasionally cases occur with a large effusion and comparatively little distress in breathing.

Rise of temperature is said to occur always after effusion of blood into the pleural cavity. On admission to hospital the temperature in the majority of cases was elevated to 100° or 101°, and even to 103° or 104°, and reached normal in about ten to fourteen days in sterile cases; but in 9 cases the temperature was normal on admission, and remained so. *Fig.* 253 shows a typical temperature chart from a case of sterile hæmothorax.

Hæmothorax was present in varying degree in all except 5 cases. In 49 the effusion was sterile, in 10 pus was mixed with blood, and in 11 the blood was found to be infected on bacteriological examination.

Pneumothorax was present in 14 cases. In 8 the pneumothorax communicated with the outer air through an opening in the pleura, and in 6 the pneumothorax was closed. The pneumothorax was never simple, but always associated either with blood alone or with blood and pus.

Bronchitis in varying degree was present in most cases.

Surgical emphysema was present in 12 cases. It was never very extensive, and required no special treatment.

Of the 75 cases admitted to hospital, 56 were wounded by rifle bullets, and 19 by shrapnel or bombs. The latter wounds were more severe as a rule. A large proportion of projectiles were retained in the chest. This was the case on admission in 35 instances—26 bullets and 9 pieces of shrapnel: 4 rifle and 4 shrapnel bullets were extracted from the chest wall or the pleural cavity, and 27 patients were discharged from hospital with the projectile still retained and apparently causing no symptoms. The presence or absence of the missile seems to make little difference to recovery.

Of the entire series of 75 cases, only 5 had no effusion into the pleural cavity.

The cases could be divided into two distinct classes:

A. Those with penetrating wounds which were healed or healing at the time of admission into the base hospital. This class may be subdivided as follows: (1) Those with hæmothorax; (*a*) Sterile, (*b*) Infected—(i) from without, (ii) from within; (2) Those without hæmothorax.

B. Those with penetrating wounds opening into the pleural cavity at the time of admission. In this class all had empyema on the side of the injury.

The first class contains the larger proportion of the cases, and they are much more favourable for treatment. There were 67 cases in this class: 66 recovered, and 1 died of sepsis. The large majority had a larger or smaller effusion of blood into the pleural cavity. As stated above, only 5 cases with definitely penetrating wounds of the lung showed no evidence of effusion. The great majority of the effusions were bacteriologically sterile, and consisted generally of brownish liquid blood. In cases which were aspirated, this blood generally clotted in the vessel after being drawn off.

In the second class the wounds were much more severe, and there was

great destruction of the chest wall. The mortality was very high. All the cases were very ill and septic on admission; all had pyohæmopneumothorax, and drainage of the empyema did not give much relief. There were 8 of these cases, with 7 deaths. Only one case recovered where the pleura was perforated at the time of admission, and where air entered the pleural cavity with respiration. The period that elapsed between the time of injury and death varied from ten to twenty-one days. Post-mortems showed in all cases extensive laceration of the lung, generally with a lung abscess spreading from the bullet track. Abscess of the mediastinum occurred in two cases.

In the foregoing series of 75 cases, 67 recovered and 8 died. Sepsis was the only cause of death. All the cases had been moved from the firing line to the base by hospital ship immediately after the injury, and no untoward results from early removal were noted. Of the 5 cases with no effusion into the pleural cavity, all recovered completely without special treatment. In 70 cases effusion of blood occurred; in 49 of these the effused blood was bacteriologically sterile, and all recovered; in 11 there was early or mild infection, and all recovered; the remaining 10 had a considerable amount of pus in the pleural cavity, with septic absorption, and 8 of these died of sepsis.

Treatment.— All cases of perforating wounds of the chest must be carefully watched from the time of injury. The immediate symptoms generally improve when the patient is kept quiet. Hæmoptysis ceases spontaneously in nearly all cases. At the time of injury morphia may be given, and any bleeding from intercostal arteries should be arrested; but as a rule no further treatment is necessary beyond keeping the patient quiet.

On admission to hospital, when there is no effusion into the pleural cavity no special treatment is necessary, and recovery is rapid.

When effusion is present, the chest should be explored at any early date, and the fluid examined bacteriologically. When the fluid is found to be sterile, it may or may not be removed: in cases where the effusion is large, with marked dyspnœa and much displacement of the mediastinum, it is always advisable to aspirate the fluid; when the effusion is not large, it may be aspirated or left alone. In cases where it is left alone, recovery is rather slower. Of 49 cases of sterile hæmothorax, 16 were aspirated and 33 were not. All recovered, and all were discharged in four to six weeks; in both series there remained some impairment of note over the base on the side of the effusion.

When a hæmothorax is found to be infected, it should be aspirated or drained early. It was found in this series that resection of a portion of rib, and drainage by tube, gave most satisfactory results. Of 5 cases where fluid was aspirated, resection of a rib was performed later in 4. Of 11 cases of infected hæmothorax, 10 had a portion of rib resected; all recovered.

When definite pus is present, the pleural cavity should be drained at the earliest possible time by the resection of a portion of a rib and the insertion of a large drainage tube. Where a large empyema cavity exists, weak iodine body baths were found beneficial; or gentle lavage of the pleural cavity through a tube without pressure may be employed. There were 10 cases of

pyothorax: 8 were associated with open wounds, with 7 deaths; 2 with closed wounds, with 1 death.

The majority of the cases occasioned no anxiety from the time of admission; their recovery was uninterrupted, although signs of fluid were present for a long time after the patients were apparently well. It was found beneficial to get them up early, even before the temperature was quite normal, and to practise gentle exercises and breathing exercises.

It is impossible at present to say what will be the after-history of these cases, and whether they will be able for the most part to perform their ordinary duties. Probably in all cases the pleura must be much thickened, and there will be numerous adhesions binding down the lung, and impairment of its movement, resulting in shortness of breath and fatigue on exertion. It would be most useful to follow the after-history, but the difficulties of doing so are very considerable.

I have to thank Lieutenant-Colonel Robinson, in charge of the 21st General Hospital, for permission to publish these cases.

CASES PRESENTING UNUSUAL FEATURES.

I.—Three Cases of Penetration of the Chest over the Precordium.

Case 1.—Private T. C. was hit by a rifle bullet on July 13 when standing in a trench. He had severe pain and much dyspnœa, and hæmoptysis immediately after injury. He was admitted six days after being wounded, with severe dyspnœa and much cyanosis, temperature 102°, pulse 98, respiration 36. The bullet entered the left side of the chest one and a half inches above and three-quarters of an inch inside the nipple line. The wound of exit was in the tenth space in the mid-scapular line. Both wounds were healed on admission. There was extensive surgical emphysema over a large area of the chest around the entrance wound, extending from the clavicle to the sixth rib in front. The left side of the chest moved badly. In front there was a markedly hyper-resonant, almost tympanitic, note over the whole of the left side. Cardiac dullness was absent, and the apex beat was not palpable. On auscultation, the maximum intensity of the apex beat was in the sixth space half an inch external to the left margin of the sternum. Behind, there was marked dullness on the left side from the base to the spine of the scapula. There was a well-marked *bruit d'airain*, and there were other signs of pneumohæmothorax. The chest was explored, and a small quantity of dark brown liquid blood drawn off was found bacteriologically sterile. The temperature showed a daily excursion of two to three degrees, from 100° to 103°; it gradually subsided, and reached normal seventeen days after admission. The surgical emphysema cleared up completely three days after admission, and the signs of pneumothorax cleared up within a week, leaving the signs of simple hæmothorax. The patient had no special treatment, and was discharged well within a month.

The features in this case were (*a*) The track of the bullet; and (*b*) The general appearance of sepsis in a case where examination of the effused blood showed the latter to be sterile.

Case 2.—Bandsman S. H. was carrying a stretcher on June 17, when he was hit by a rifle bullet. He walked five hundred yards after being hit, and said he felt very little discomfort until he began to feel weak. There was little bleeding from the wound at the time, no hæmoptysis, and little dyspnœa. He was admitted on June 24, feeling very well, with little distress, and with normal temperature, pulse, and respiration. The bullet entered the fourth space just outside the right sternal

line, at the junction of the cartilage with the sternum. The wound was healed on admission, and the bullet retained in the chest. He had signs of effusion at the left base. On June 27 he had severe pain in the left side, and was found to have a well-marked pericardial friction rub. The temperature was elevated to 101°, respiration 40, and pulse 103. The chest was aspirated on June 30, and a pint and a half of dark brown fluid blood was removed from the left pleural cavity, and was found to be sterile. There were signs of fluid in the pericardium, which was possibly serum, but it was not explored. *X*-ray examination showed the heart area greatly enlarged and increased in density. The patient was much relieved by tapping, and the temperature came gradually to normal in three weeks, when signs of effusion in the pericardium had disappeared.

The interest of this case is concerned mainly with the track of the bullet, which must have pierced the pericardium, and possibly also the heart, causing no immediate symptoms, but the later development of a simple pericarditis, with complete recovery.

Case 3.—Private P. M. was hit by a rifle bullet on Sept. 1. He had hæmoptysis for four days and much dyspnœa, but no loss of consciousness. He was admitted on Sept. 9, and was not very ill. On admission, the temperature was 101°, pulse 98, and respiration 24. The wound of entry was half an inch above and two inches internal to the nipple line on the left side. The wound of exit behind was three inches from the spine, over the eighth rib. There were signs of a large hæmothorax on the left side, with considerable displacement of the heart to the right. There was no evidence of damage to heart or pericardium. The hæmothorax was found to be sterile, but fluid was not aspirated. The temperature ran an irregular course, varying from 99° to 101°, and then gradually to normal, in fifteen days. The patient was discharged after four weeks, with very much diminished evidence of fluid.

In this case the entrance of the bullet was over the cardiac area, but no serious results followed.

II.—Two Cases of Penetration of Both Lungs and Mediastinum, with Double Hæmothorax.

Case 4.—Private W. J. was hit by a rifle bullet on Aug. 31. He had hæmoptysis lasting a day and a half—about a cupful altogether. He also had well-marked dyspnœa. He was admitted to the base hospital on Sept. 9, with slight dyspnœa and little elevation of temperature. The bullet was found to have entered the fourth space on the right side, one inch internal to the mid-clavicular line. It passed through the lungs, and evidently through the posterior mediastinum, to emerge in the fifth intercostal space in the posterior axillary line on the left side. There were signs of a large effusion on the right side and a smaller one on the left, with some cardiac displacement to the left. The hæmothorax on both sides was sterile, and was not aspirated. Signs of effusion had decreased greatly on discharge.

Case 5.—Lance-Corpl. C. W. was hit by a rifle bullet on Sept. 8 while bending. He had much dyspnœa and hæmoptysis directly after the injury. He was admitted to the hospital on Sept. 14; his temperature was 101°, pulse 98, respiration 26. The entrance wound was in the fourth intercostal space on the right side, one inch behind the posterior axillary line. The bullet passed through both lungs, to emerge through the left shoulder. There were signs of a large effusion in the right pleural cavity, and of a smaller effusion at the left base; both were sterile. Two pints of sterile blood were removed from the right pleural cavity on Sept. 15. The patient made an uninterrupted recovery, and was discharged within a month with few physical signs.

III.—Large Hæmothorax with relatively Few Symptoms.

Case 6.—Corpl. C. O. was wounded on July 13 by a rifle bullet while crouching in a trench. He had no hæmoptysis, and little distress in breathing. On admission, seven days after the injury, the patient was very comfortable, he had no dyspnœa, and pulse, temperature, and respiration were normal, and remained so. The bullet

entered through the second intercostal space on the left side in the mid-clavicular line, and was retained, but could not be located by *x* rays. There were signs of a large hæmothorax on the left side, with dullness extending almost to the apex behind, and to the fourth rib in front. The heart was considerably displaced to the right. The chest was explored, and the dark brown fluid blood withdrawn was found to be sterile. The chest was not aspirated, and the patient was discharged on Aug. 20 with physical signs of effusion very much diminished.

IV.—Three Cases of Infected Hæmothorax where Apparently Pure Blood withdrawn by the Exploring Syringe was found to be Infected on Bacteriological Examination.

(There were 11 cases of infected hæmothorax; the most common infections were the pneumococcus and staphylococcus. All recovered.)

Case 7.—Private G. S. was hit by a rifle bullet on Aug. 18 while sleeping. At the time of injury he had much distress in breathing, and hæmoptysis which lasted for two days. He was admitted to hospital on Aug. 24, with temperature 101°, pulse 96, and respiration 32. The entrance wound of the bullet was on the right side in the anterior axillary line between the eighth and ninth ribs. The bullet was retained. There were signs of effusion on the right side, extending to the spine of the scapula behind. The heart was displaced to the left. On Sept. 3 his temperature rose to 104°, with pulse 106, and respiration 36, and the signs of fluid had increased. The chest was explored, and dark brown fluid blood was drawn off by the syringe. This was examined bacteriologically, and pneumococci were found to be present. A portion of the ninth rib was resected, about two pints of infected blood were evacuated, and the pleural cavity was drained by tube. The patient recovered rapidly, and the temperature became normal in about three weeks. On discharge, the wound was healed and the lung was expanding.

Case 8.—Private A. P. received a bullet wound in the chest on Aug. 9. He had hæmoptysis half an hour after the injury. Dyspnœa was not marked at the time, but increased later. He was admitted to hospital on Aug. 14, and was found to have a bullet wound in the fifth right intercostal space just behind the posterior axillary line. The fourth and fifth ribs were fractured at the site of injury. The bullet was retained. There were signs of effusion into the right pleural cavity, extending to the angle of the scapula behind. On Aug. 19 one pint of sterile blood was aspirated from the right pleural cavity. On Aug. 25 signs of hæmothorax had increased, and the temperature rose to 103°. He was again aspirated, and the fluid was bacteriologically examined, and found to contain pneumococci. On Aug. 26 a portion of the ninth rib was resected, and the pleural cavity was drained by tube. A deformed bullet, found free in the pleural cavity, was removed. The patient developed bronchopneumonia, which delayed his convalescence. He was discharged on Sept. 28 with the wound healed, and with signs of air entry into the base of the right lung.

Case 9.—Private F. G. received a bomb wound in the back on Aug. 6, while standing on the side of a trench. He fell into the trench, a distance of five feet, when he probably fractured a rib. He had a little hæmoptysis at times, and he coughed up blood for ten days. He had much dyspnœa, and a great deal of pain on the right side. He was admitted to hospital on Aug. 13, with slight elevation of temperature and little dyspnœa. He had a wound in the back on the right side, two inches from the spine, at the level of the eighth rib. This rib was fractured at its angle. On examination, he showed signs of effusion on the right side, with dullness from the base to the angle of the scapula. The apex beat was in the fourth space, half an inch outside the nipple line. On Aug. 18 his distress became greater, and he had much pain in the right side. The effusion was found to be increasing, and the dullness and absence of breath sounds extended to the apex. The fluid was aspirated, and three pints of dark fluid blood were drawn off. The blood clotted in the vessel. After aspiration the patient was much more comfortable, but was

distressed again on the following day, and on the 20th the signs of fluid had again reached the apex, and the mediastinum was considerably displaced to the left. The apex beat was in the fifth space in the anterior axillary line. The chest was again aspirated, and two pints of blood were withdrawn, which was found on bacteriological examination to contain streptococci. A portion of the eighth rib was resected, and the chest drained. Subsequently the pleural cavity was washed daily by weak iodine solution through funnel and tube. The patient made an excellent recovery, although convalescence was delayed by an attack of dysentery. On discharge, on Oct. 1, the wound was healed, and a definite amount of air was entering the lung.

V.—Pyothorax followed by Recovery.

Case 10.—Private G. N. received a bullet wound in the back on Aug. 8. He had no hæmoptysis and no dyspnœa. He was admitted to hospital on Aug. 13, with a temperature of 100°, pulse 106, and respiration 30. He had a bullet wound opposite the third lumbar vertebra one inch to the left of the spine, and no exit wound. There were signs of effusion in the left chest from the base to the spine of the scapula. The chest was explored, and a small amount of blood and pus withdrawn, which was found to contain streptococci. A part of the twelfth rib was excised, and one pint of blood and pus was evacuated from the pleural cavity. The bullet casing was removed from a pocket behind the eleventh rib. The cavity was drained by tube, and a tube was also inserted to drain a perinephric collection of pus. The patient had daily body baths of weak iodine. He made a complete recovery, and the wound was healed on discharge.

VI.—Pyopneumothorax followed by Recovery.

Case 11.—Private G. K. was hit in the back by a bullet on Aug. 19. He had much dyspnœa and hæmoptysis at the time of injury. He was admitted to hospital on Aug. 24 with a temperature of 101°, pulse 96, and respiration 30. There was a healed entrance wound in the eighth space behind, in line with the angle of the scapula. The exit wound was in the first intercostal space, one inch outside the border of the manubrium sterni. The anterior wound was gaping, exposing the pleura, and in the centre of the latter there was a small pinhole puncture, with air entry during respiration, and some oozing of pus. There was surgical emphysema for a radius of three inches around the wound. There were signs of a pneumohæmothorax, which was evidently infected. A portion of the ninth rib was resected in the posterior axillary line, and one pint of blood and pus evacuated. The upper wound was also explored, and half a pint of pure pus evacuated, evidently a separate loculus shut off from the lower collection. Both wounds were drained by tube. On discharge, both wounds had healed, and there were signs of lung expansion.

VII. Two Cases of Pyohæmothorax with Open Pneumothorax. Post-mortem Findings.

(Altogether there were 8 cases, with 7 deaths.)

Case 12.—Private G. O. was digging on Aug. 7 when he was hit by a sniper. He gasped for breath, and coughed up a little blood immediately after the injury. He was admitted on Aug. 14, very ill, cyanosed, and gasping for breath, with a temperature of 102°, pulse 108, and respiration 36. There was a bullet wound through the middle of the right clavicle, with fracture of the clavicle and an open wound into the pleural cavity. Air entered the pleural cavity with respiration. The exit wound was in the ninth space in the mid-scapular line. The intercostal spaces on the right side were obliterated, there was marked hyper-resonance over the whole of the right chest, absence of breath sounds over the lower lobe, and there were faint cavernous breath sounds over the upper lobe. Posteriorly there was dullness from the base to the angle of the scapula. Metallic tinkling was well marked, and the coin sound was elicited. There were coarse râles and rhonchi over both lungs, and a friction rub from the second to the fourth rib in front. The patient died twenty-four hours after admission.

Post-mortem Examination.—The bullet track passed through the clavicle downwards and backwards, fracturing the second to the tenth ribs, and emerging in the ninth space in line with the angle of the scapula. The fractures of the clavicle and ribs were comminuted, with extensive laceration of the parietal pleura by sharp spicules of bone. There was wide laceration of the posterior parts of the right upper and lower lobes in the line of the fractured ribs, and complete collapse of the right lung. The pleural cavity contained air, and there were about two pints of blood-stained pus. There were also a few patches of bronchopneumonia of the left lung, with partial collapse.

Case 13.—Private J. S. received a bomb wound of the chest on Aug. 2. He had much dyspnœa, and coughed up about a pint of blood at the time of injury and for two hours afterwards. He was admitted on Aug. 13, with much distress in breathing, and seemed very ill. The temperature was 100·8°, pulse 136, respiration 38. He had a perforating wound on the right side of the chest communicating with the pleural cavity. The bullet entered between the fifth and sixth ribs in the mid-axillary line, fracturing the ribs. The projectile was retained. Examination showed signs of effusion of blood and air into the pleural cavity. The wound was opened up, a large collection of blood and pus evacuated, and a drainage tube inserted. The draining of the pyothorax gave little relief; and the patient developed pneumonia on the left side, and died on Aug. 20.

Post-mortem Examination.—The projectile fractured the fifth and sixth ribs in the right mid-axillary line, passed to the left upwards and forwards through the right lung, and finished in the mediastinum behind the upper part of the manubrium sterni. A fragment of bomb casing, 1 cm. in diameter, was found in a large abscess cavity just behind the sternum, with some erosion of the bone. There was a wide track full of pus through the lung, with signs of purulent bronchitis and peribronchial pneumonia in the surrounding lung tissue, and also bronchopneumonia of the left lung.

THE FLAPLESS AMPUTATION.

By Captain M. FITZMAURICE-KELLY, R.A.M.C. (T.C.)

The present war has raised many surgical problems, but the chief of them is the problem of wound infection. All controversies centre round this, and the controversialists may be roughly divided into two camps: those who have seen; and those who—not having seen—are altogether unable to believe the conditions with which we have to deal. So that the quarrels of rival schools are to be explained as a vast misunderstanding, which it is our business and our duty to clear away as soon as possible.

One offshoot of this great debate, but essentially a part of it, is the question of amputations. The early days of the war produced conditions which we had never seen or dreamt of, and these called for new methods. In October, 1914, I had the temerity to adopt a method which reverted to the dawn of surgery, and later, after due trial, I advocated it publicly[1] in certain well-defined cases, and with a prescribed, though simple, technique. That method, called variously the flapless amputation, the guillotine amputation (a bad name), and the amputation *en saucisson* (a very bad name), has had a curious fate; approval almost unanimous from those at the front, and obloquy almost universal from those at home. I will not say that I am unduly humbled by the partition of praise and blame, and when invited by the British Journal of Surgery to re-state the case, I accepted with the reluctant gladness of one who feels that it is of the first importance to make the position clear, but whose literary activities are hampered by a vast deal of other work to hand.

It will, perhaps, be well first to enumerate the reasons which have led to the adoption of this method, and which, in my opinion, admit of no other course; and then to deal with such criticisms as have reached me.

When I first arrived in France, I heard horrifying accounts of the ravages of gaseous gangrene, and of the appalling results of amputation; and when I saw the cases, it was easy to believe. The condition is rarely seen at the base now, thanks to the good work of the clearing hospitals; but in the early days it was quite common. Large segments of the limb, often above the elbow or knee, reached the base hospitals in a totally gangrenous condition, and a large area of the limb above was hard and brawny, with the typical brown discoloration, frequently extending to the trunk. In such cases, amputation seemed hopeless, and I am afraid our first case died without anything being attempted for his relief. In the next case, with gangrene to the middle of the arm, I decided to attempt amputation; I divided the skin a quarter of an inch from the gangrenous margin, and after allowing for retraction, I divided the muscles, and then the bone at the level to which the muscles retracted. To my surprise, the patient's general condition improved at once,

and the threatened tissue recovered rapidly. He was evacuated to England eight days later.

Thinking it over, it appeared to me that the method which gave the best chance of life to the patient was that which left the nutrition of the stump unimpaired to the end; in which, in other words, the nutrition was not cut off by the undermining of flaps; and now, after some sixteen months further experience, I consider *gaseous gangrene* as an absolute indication for a flapless amputation. Other conditions for which I employ the method, though for different reasons, are certain cases of *compound comminuted fractures* and of *multiple wounds*. For the sake of clearness, it will be well to consider these separately.

1. **Gaseous Gangrene.**—In these cases we are dealing with a spreading infection, often of most appalling virulence. Part of the limb is gangrenous and crepitating, often with gas-containing bullæ in the skin, and beyond this part is an infiltrated œdematous area, with a yellowish-brown staining of the skin, which rapidly becomes involved in the gangrenous process. Often no healthy skin is left in the limb, and experience has shown that flaps cut from the threatened tissue almost invariably slough, and become the starting-point of a further spreading infection. If, on the other hand, a flush amputation is done close to the edge of the gangrenous parts, recovery of the threatened tissue is the rule; and not only is life saved, but a maximum economy of the limb is achieved.

Specially important cases are those where the gangrene extends close but not up to the knee, hip, and shoulder-joints. In gangrene reaching to just below the knee—a very common variety—a flap amputation, to be safe, would need to be through the middle or upper third of the thigh. If, however, the skin can be divided just below the knee, and the bones sawn below the tubercle of the tibia, there is little retraction of the skin, since the quadriceps and hamstrings are intact, and there is ample material for a trans-condylar amputation later. Similarly, at the hip-joint, a transverse amputation which is practically the first stage of an Esmarch's amputation often saves the situation, while the mortality of disarticulation at the hip-joint is so great as to make it almost unjustifiable. And at the shoulder, as in my first case, it can be used as a first stage of a shoulder-joint amputation, when immediate disarticulation would be much more risky.

2. **Compound Comminuted Fracture.**—Before defining certain cases in which I think the flapless method applicable, perhaps I may be allowed a short digression on the conditions present in the compound fractures due to shell wounds, and wherein they differ from those met with in civil practice. In the compound fractures we are accustomed to treat in peace time, the protruding bone is perhaps infected, but the infection is usually not severe, and is confined to the protruding bone and the immediate focus round it—that is, it is strictly localized. In gunshot fractures, on the other hand, a piece of metal enters the limb, carrying with it pieces of clothing coated with mud from a highly manured soil; it strikes the bone with explosive violence, splintering perhaps five or six inches of the shaft and lacerating the soft tissues widely; while the exit wound is an enormous rent made by pieces of bone as well as the projectile. And be it remembered

that all this area of broken bone and lacerated tissue and blood-clot, perhaps as large as a cocoa-nut, is at once and irretrievably infected with anaerobic and pyogenic organisms.

In these conditions, local cleansing at the earliest possible moment, and free drainage, do what they can; when they fail, and the patient's life is in danger, amputation is called for. In such a case the infection is very widespread; the whole limb is often œdematous, and any amputation, properly so called, is out of the question. In these cases I think a flapless amputation, at or just above the site of fracture, is the best treatment, for it seems to me that the best possible drainage is the dominant need, and that a transverse open division of the tissues, with removal of the bone fragments, realizes the ideal of perfect drainage. It may be even advisable to divide the tissues below the highest point of the fracture, and remove the loose pieces from the stump.

3. **Multiple Wounds.**—These are fairly common in later war surgery, and are particularly often the result of bomb-wounds. It often happens that a hand or a foot is mangled almost beyond recognition, and that the rest of the limb is literally peppered with fragments, every one of them causing a septic wound. Here a flap amputation is out of the question, and a simple transverse section of the limb, and cleaning up of the septic face, with a view to subsequent regularization of the stump, is obviously the most reasonable and the most economical course. My friend, G. V. Legros,[2] has recorded a case of the kind with an excellent result.

So much for the indications. I have dwelt on them at some length, because it seems advisable to make it clear that the method is not a routine one, but is designed to meet new difficulties and dangers, and is used in special cases for quite definite reasons. It has, in my opinion, certain advantages as well as drawbacks, but I believe the advantages are solid, and that the drawbacks are shared with the classic methods. The advantages claimed are:—

1. *That it saves life.* This is a question that can only be judged by those who see the wounded early; but I am not alone in believing that a vast number of lives have been saved by it in this war, and that many who have reached home, and been the subjects of serious complaints in the matter of painful or unsightly stumps, could not otherwise have reached England at all.

2. *That it saves length of limb.* This is important, because the burden of many of the charges brought against the method is that the necessity of a second amputation sacrifices length of limb unnecessarily. A moment's consideration will make it obvious that nothing can be lost, and much can be gained. The skin is divided at the lowest possible point, lower than any operator would dare make the lowest point of his flaps; and, as is shown in the brief description of the method that follows, any subsequent retraction can be regained by extension.

3. *That the risk of secondary hæmorrhage is lessened.* It is more than lessened; as far as my experience goes, it is prevented; and it may be noted that at a recent discussion on secondary hæmorrhage in France, no one present had seen secondary hæmorrhage in a flapless amputation. In flap operations,

on the other hand, especially those that have been stitched, secondary hæmorrhage is common, even in cases where the wound appears fairly clean, or at any rate is not suppurating freely. Personally, I believe secondary hæmorrhage to be due to the quality of the infection, and that its recrudescence in this campaign is due to infection with organisms differing from those in the common wound-infection of civil practice; but this is too large a question to discuss here. However, in the opinion of those best able to judge, this immunity constitutes one of the most solid advantages of the method.

4. *That it arrests the spread of infection, whereas in flap amputations sepsis often recurs in the flaps, and spreads up from their base.* As a case in point, I saw recently an injury where a shell-wound had destroyed the posterior part of the os calcis and opened the ankle-joint. Personally, I should have amputated through the malleoli; actually, a flap amputation was performed through the middle of the leg; three days later I was consulted as to the propriety of re-amputating above the knee for spreading septic infection!

5. *That it is possible where no other method is possible.*

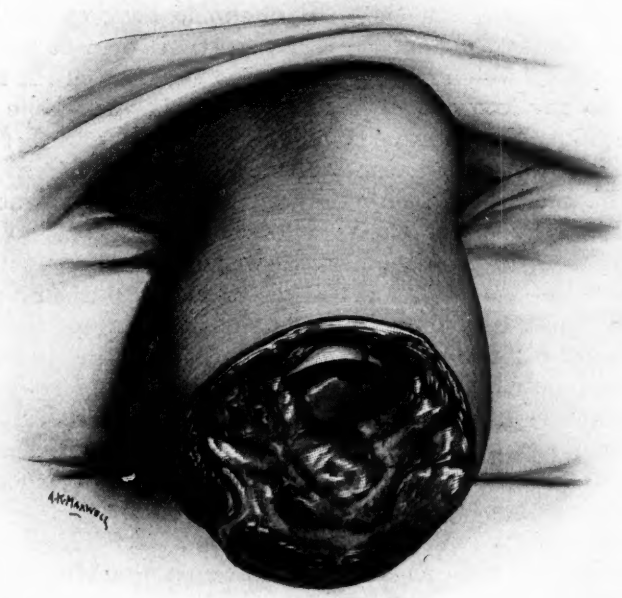

FIG. 254.—FLAPLESS AMPUTATION OF THE LEG.

The case shown in *Fig.* 254 was one of gunshot fracture of the left leg, followed by gas gangrene of the foot. The amputation was made close to the site of fracture (below the highest point reached by it).

The drawing, made ten days after the operation, shows very slight retraction of the soft tissues, and radiation of the original fracture in the tibia above the level of the amputation.—[*Ref. No.* 41.]

Now, as to the method: I have objected above to the term 'guillotine' amputation, because I think it gives a false idea of the method, which,

though simple, is not quite so simple as that. There is little to add to the original description; the skin and deep fascia are divided, usually in circular fashion, but sometimes more skin can be gained by making the incision oblique; after retraction has occurred the muscles are divided at the level of the retracted skin—not too quickly, so as to allow a retraction of the layers; then the bone is sawn flush with the muscle; vessels are secured and nerves carefully shortened: that is all. The surface is slightly concave at first if the operation has been properly done, but soon becomes convex from further retraction. This, however, once the face is fairly clean, is overcome easily by extension. For this a device suggested by Captain C. W. G. Bryan is the best. Strips of strapping are laid up the limb to the joint above, fixed with circular bands, and then carried down to a large ring of malleable aluminium to which a weight extension is attached. The apparatus looks very like the horn of a gramophone, and in the middle the stump is easily accessible for dressing. In this way all that has been lost by retraction can be rapidly regained, and it is rarely necessary to do more than remove a length of bone with a Gigli's saw.

It is perhaps natural that the method should have excited criticism; a reversion to so primitive an operation was certain to meet with opposition. Most of the objections which have reached me have been in the form of vague rumours—few, to my knowledge, have appeared in the public press; some, I believe, have taken the form of confidential reports, and I should like to see them in public with their authors' names attached. At first, the general burden was that the amputation was done through sheer ignorance of the classic methods; I hope, for the sake of his reputation, no one has put his name to that. For my own part, I was brought up in the school of Edmund Owen, who—though it was his least title to repute as a surgeon—was incomparably the best I have ever seen in the designing of flaps; and I am not likely to forget his skill or teaching when the appropriate moment comes again to try and follow them.

Other objections—less frivolous—of which I have heard, are:—

1. *The necessity of a second amputation.* This I assumed in my original article;[1] and it seems to me a drawback that is amply compensated for by counter advantages.

2. *The waste of limb through a second amputation.* This I deny utterly. I have already discussed the question under the advantages claimed, and would only insist once again that a flap amputation almost always results in loss of length of limb; that sloughing of the flaps frequently reduces them to what is practically a flapless amputation higher up the limb; and that many cases abused as flapless amputations at home, started their career as flap amputations unstitched, and retraction has done the rest.

3. *The danger to the patient of the long and painful convalescence due to the open granulating surfaces.* But how avoid it? To sew up flaps is to court disaster; to leave them open means an even larger granulating surface.

4. *The risk of sepsis when the secondary amputation has to be done without waiting for complete healing.* All my experience has been in France, and a vast

majority of the cases go home before a secondary operation is done; but it seems fairly obvious that the sepsis in an open granulating surface is less virulent than the infections with which we have to deal; and if the argument has any force, it tells *a fortiori* against a flap amputation at an early stage.

5. *The prevalence of septic ascending neuritis.* Of this I have no experience, but probably a proper shortening of the nerves would avoid it.

Finally, I would urge on those at home, and especially on those who have influence to use or abuse, the extreme and instant importance of the question. I know well that a mass of prejudice needs to be overcome: in the debate at the *Société de Chirurgie de Paris* last year, Quénu[3] gave a straightforward account of two identical cases, one of which he had saved by a flapless amputation, and the other lost by disarticulation at the hip-joint; and he was met, not with argument, but with rhetoric! But this is not a question of the reputation of this man or that; it is a question of life and death for men to whom we owe the best we can give; and on their behalf I hope it is not too much to ask those in England to allow due weight to the opinion of surgeons who know the conditions, and have thought of nothing else for many months.

REFERENCES.

[1] Fitzmaurice-Kelly, *Lancet*, 1915, Jan. 2.
[2] Legros, *La Presse Médicale*, 1915, Jan. 21.
[3] Quénu, *Bulletins et Mémoires de la Société de Chirurgie de Paris*, 1915, April 7.

A CASE OF TRENCH-FOOT IN THE ABSENCE OF FROST.

UNDER THE CARE OF CAPTAIN S. G. LUKER.

THE patient was admitted to hospital on October 8, 1915, suffering from a gunshot wound of the abdomen and left arm, and 'frostbite' in both feet.

He was wounded about dusk on September 27, when advancing up a hill, and fell on the slopes of the hill about forty yards from the German barbed wire. Owing to rifle and machine-gun fire he remained for practically two

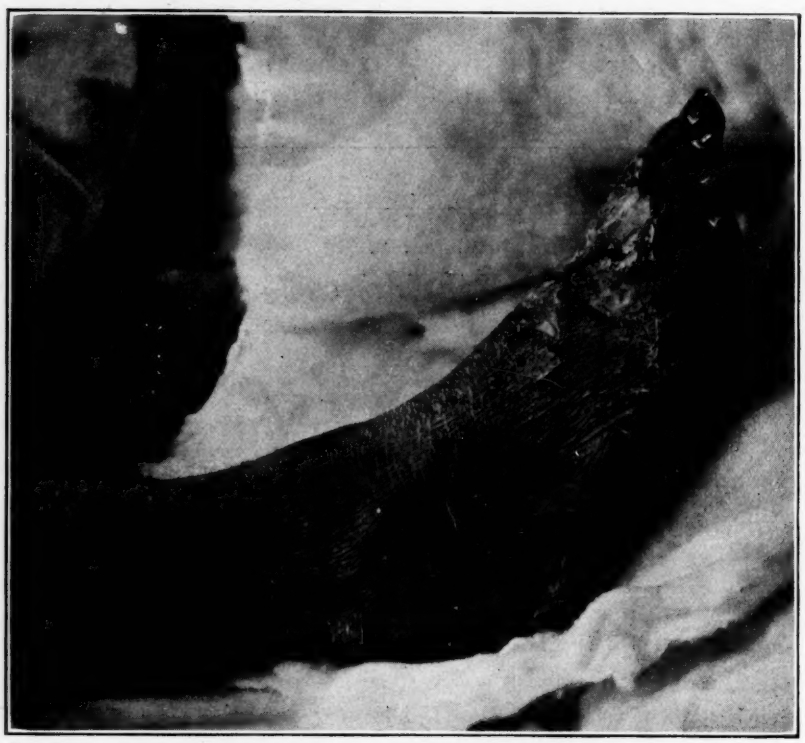

FIG. 255.—TRENCH-FOOT. Showing dorsum of right foot.

days without moving. He made a hole in the ground for his head and shoulders, and lay looking downhill for safety. He remained out six more days before being brought in by the French. During this time he crawled about at night, giving water to some wounded men and attempting to bring others back with him, but was too weak. The place where he lay was fairly dry; it rained a little the first morning, but was fine most days. There was no frost. He noticed his feet were turning cold and becoming numbed during the first

night, but he had no pain. He was wearing a pair of old boots which he had done marching in, and which were not tight; he took them off on the last day he lay out. The puttees he was wearing were not tight, and never were wet through, and he took them off on the third day. There was plenty of food and water near, but he ate practically nothing.

The patient had worked on a farm before the war, and had chilblains every winter.

On admission the wounds of both left arm and epigastrium were found to be small and slight.

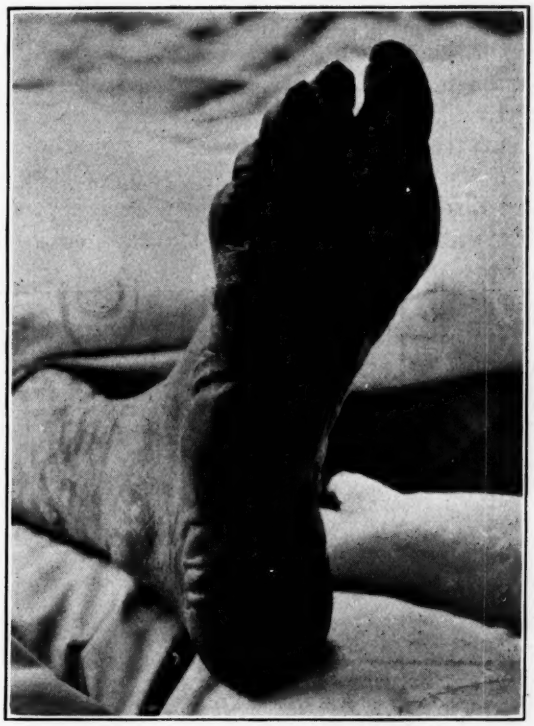

FIG. 256.—TRENCH-FOOT. Showing sole of right foot.

In the *right foot* the toes were blue and cold, the extremity of the foot blue but not cold, with an irregular and indefinite line of demarcation running round the sole of the foot about two inches above the root of the toes, and on the dorsum about one inch above the root of the toes. Superficial sensation in the toes was absent; deep was present, except in the big toe. In the foot superficial sensation was present, but numbed; deep present. The foot and ankle were red, hot, and œdematous. There was no pain.

In the *left foot* the toes were bluish at the tips, and sensation was impaired; the dorsum of the foot was rather pink. No pain.

The *treatment* consisted in the use of a dusting powder containing starch, boric acid, zinc, and salicylic acid, and the foot was bandaged over wool.

Progress.—The big toe of the right foot became completely mummified; the other toes appeared to be gangrenous to a considerable depth. The line of demarcation was now definite (*Figs.* 255, 256). Portions of black skin sloughed away between the toes. Later, the affected parts became bluish-black and dry, except for slight moisture where small sloughs had separated between the toes.

Oct. 29.—Gangrenous parts now began to separate. The temperature suddenly rose to 104°.

Nov. 1.—The temperature remained high from septic absorption.

Operation.—Amputation was done through the tarso-metatarsal joints. The sole-flap was rather œdematous, and showed progress of the infection to a higher level than would have been expected. The flaps were sutured together in the middle by three stitches. On November 3 the stitches were removed and the flaps opened up; after this they cleaned up gradually. Twelve days later three tension sutures were inserted to help bring the flaps together over the stump.

The patient was discharged to England on December 4, with the stump almost completely covered by skin. Up till the last week he showed obvious signs of the general septic condition acquired before operation.

TRAUMATIC RUPTURE OF THE COMMON BILE-DUCT IN A BOY SIX YEARS OLD.

By GEORGE E. WAUGH, London.

Master L. H., age 6, was knocked down and run over by a motor-car on July 9, 1915. He was seen at 6 p.m., three and a half hours after the accident, in consultation with Dr. Eustace Harwood. The front wheel of the car had passed obliquely across the abdomen and thorax from the right iliac spine to the left axillary region. He had not been rendered unconscious, but, as he explained himself, he had been badly 'winded,' and was still suffering from slight 'stitch' on the right side whenever he took a deep breath. There were some surface abrasions on the body, but no bones were broken. The general condition of the patient was good, and considering the nature of the accident and the age of the patient, the amount of shock was comparatively slight. The pulse-rate was 100, temperature 98·8°. There was no evidence of head injury, and from the condition of the patient at such an interval from the time of the accident, grave internal hæmorrhage could be excluded. The problem of injury to an internal viscus remained for consideration. He passed eight ounces of normal urine three hours after the accident. The abdomen was tender from the bruising of the muscles, but otherwise it moved freely, was not rigid or distended, and the liver dullness was present and apparently normal in extent. A gross injury to any part of the alimentary tract seemed unlikely in the presence of these signs, and it was therefore determined to regard him as potentially a case of bruising of some part of the abdominal contents, capable of recovery if complete rest to the affected part could be achieved. He was placed in the Fowler position, continuous administration of 20 per cent solution of glucose in saline per rectum was begun, a total abstinence from anything by mouth—including water—insisted on, and $\frac{1}{15}$ gr. of morphia was given hypodermically. The principles of the treatment were, to secure such rest to the intra-abdominal contents that any injury to the peritoneum should virtually be in splints, and at the same time to guard against a spontaneous acetonæmia so readily induced in children by starvation, and so grave in its consequences, by the administration of large doses of the monosaccharide glucose. An hourly record of the pulse-rate was charted.

The patient passed a good night and was free from pain next day. The pulse-rate varied between 100 and 120, as shown by the hourly chart, but at no time did it show any tendency towards a progressive increase. There were signs of an effusion of fluid into the left pleural cavity, but these disappeared during the course of the illness without any special treatment, so that the nature of the fluid was never determined. There was no change in the physical signs throughout July 10 and 11, and a normal stool was passed on July 11.

On the same evening, however, patient vomited once, and he was restless during the night. He vomited again on the next morning, July 12. A slight tumescence of the abdomen was now noticed for the first time, and a little deep-seated tenderness in the right hypochondriac region. Otherwise the abdomen was soft, mobile, and free from pain. That morning a slight yellow tint appeared in the conjunctivæ, excess of bile pigments was present in the urine, and a small clay-coloured motion came away with some of the glucose and saline solution. His temperature had never risen above 99·6° since the accident, and his pulse still fluctuated between 100 and 120. The hourly chart still did not show any tendency to a progressive rise in the pulse-rate; but—a point of great importance—it showed no tendency towards the steady fall that should have occurred had no deep-seated injury been inflicted. There was no acetone in the urine, and therefore the maintenance of the accelerated pulse-rate could not be accounted for on that hypothesis.

In view of the slight alteration in the physical signs from the evening of July 11, and the maintained increase in the pulse-rate, a laparotomy was advised, and a tentative diagnosis of rupture of the gall-bladder made. The operation was performed on the afternoon of July 12, and the abdomen opened through a vertical incision over the upper part of the right rectus muscle. The fibres of the muscle were separated, and on opening the peritoneum about a pint and a half of blood-stained bile escaped. This was gently sponged out, the general peritoneal cavity packed off, and the liver rotated for an inspection of the gall-bladder region. The gall-bladder itself was pink, empty, and apparently uninjured. Close to its neck a fairly large mass of dark blood-clot was encountered, and on sponging this away, a large ragged tear in the gastro-hepatic omentum below the level of the cystic duct was revealed. The portal vein was easily seen lying bare in the wound, and bile was noticed oozing freely from the margin of the tear. The smallness of the structures and the irregular laceration of the tissues rendered the identification of the duct impossible. A large rubber drainage tube was fixed by one catgut stitch to the site of the oozing, another was placed in the kidney pouch, and both were then surrounded by three gauze-ribbon strips. The abdomen was closed in layers. The patient stood the operation well—the pulse only rising to 142, and soon coming down to the previous level. His general condition was so satisfactory that at the end of thirty-six hours mouth-feeding with fluids was begun. Bile escaped freely for three days through the large tube, but then stopped rather abruptly.

The patient's general condition remained very satisfactory, but by July 19, seven days after operation, slight jaundice once more appeared, bile pigment was present in the urine, and the upper part of the abdomen was swollen. Open ether was therefore administered again, and the upper part of the wound carefully opened. The general peritoneal cavity was found to be firmly sealed off by dense adhesions, but access along the track of the tube to the region of the foramen of Winslow was easy. It was then found that the swelling of the upper part of the abdomen was due to a large collection of bile—about two pints—in the lesser sac. This was emptied out by gentle pressure, and a tube passed through the foramen into the sac. Another tube was left over the tear in the small omentum, and both these were again packed

round by strips of gauze. During the next two days bile escaped satisfactorily through the drainage tube, and then stopped abruptly. Blood was found in the urine for four days after the operation, and then disappeared.

The general condition of the patient was very good, the pulse-rate tended to vary between the levels 100 and 110, the bowels acted regularly, but with pale motions, and the appetite was good. Swelling of the upper part of the abdomen re-appeared, however, and from the knowledge gained at the second operation it was evident that bile was once more filling up the lesser sac. Daily measurements of the circumference of the abdomen before and after meals were instituted, and these showed a slight progressive increase in size up to July 24. On that day the increase apparently stopped, the urine became paler in colour, and a motion, containing more pigment than had been present in any other one since the accident, was passed.

It was decided to ask the help of Sir Berkeley Moynihan, who kindly saw the case in consultation with us on July 25. His advice was invaluable, and the course of action that he advocated was completely justified by the subsequent success that attended it. The interpretation placed by him upon the phenomena which were observed on July 24—that is, the arrest of increase in size of the abdomen, the increasing pallor of the urine, and the decreasing pallor of the stools—was that the torn duct was becoming closed over and healed by lymph formation, so that the flow of bile into the lesser sac was stopping, and bile was once more finding its way into the alimentary tract. The strength of the patient was well maintained, and the firm adhesions found at the second operation rendered unlikely any invasion of the general peritoneal cavity by bile. The collection of bile in the lesser sac was therefore for the time being no menace to the welfare of the patient, whilst a premature operation for its evacuation might easily disturb the process of healing of the duct. He therefore advised postponement of any further operative interference for some days, so that the healing of the duct might become consolidated—subject to the limitation that the general condition of the patient remained satisfactory. Daily measurements of the abdomen were continued, but no increase in size occurred after July 26, and the final operation for the emptying of the lesser sac was not done until August 12.

I found this a much more difficult procedure than I had anticipated. The fibres of the left rectus muscle were split through a vertical incision with its centre at the level of the umbilicus, and the interval between the lower border of the stomach and the transverse colon was sought for. The difficulty was to identify anything—and especially an interval such as this, which is not large in a child—because of the dense matting together of all the viscera as the result of the original diffusion of bile throughout the general peritoneal cavity, and the deep staining of the parts with bile, giving them the resemblance of a dark green homogeneous mass. The interval was successfully found by means of a hypodermic needle, and then a large trochar and cannula inserted along its track. From the small sac about a pint of opaque bile was slowly and carefully evacuated, and a small rubber drainage tube left in the opening into it before the abdomen was closed.

A few ounces of bile escaped during the next few days, the tube was then removed, and the subsequent convalescence was entirely uneventful.

The patient has been leading a normal life since, and on January 1, 1916, was reported to be in perfect health.

The literature upon this subject is scanty, and the condition is rare—these perhaps constitute a justification for putting the details of what is, after all, a 'freak' case upon record. A standard mode of treatment can hardly be evolved from a consideration of twenty-five cases of "rupture of the gall-bladder and bile-duct," which appear to be the only cases on record.*

W. J. and C. H. Mayo advise "immediate abdominal section, removal of the injured gall-bladder, and repair of the lacerated ducts with catgut sutures."† It would seem from the toleration of free bile in the peritoneal cavity exhibited by this patient, that "immediate abdominal section" may await the establishment of the diagnosis of an injury to the biliary apparatus; and that, even with hourly observations, signs to justify this diagnosis may not appear until two or three days have elapsed from the time of injury. Further difficulties in a child only six years of age prevent the complete carrying out of the ideal treatment which they rightly advocate. The common bile-duct is so small, that to 'suture' the torn ends would be a matter of considerable difficulty, even if they had been cut clean across. It is an insuperable difficulty in the presence of a ragged tear, where, as in this case, the ends cannot even be identified. Moreover, in a child the margin of reserve strength is so inadequate, that prolonged manipulation in the abdominal cavity, whilst resulting in a perfect mechanical achievement, may at the same time determine the death of the patient. Drainage in this case was deliberately undertaken, not from the knowledge that spontaneous healing of the duct *might* occur, but that death *would* occur from an indiscreet prolongation of the operation. Probably it would have been wiser to put a tube into the small sac at the first operation—although at that time it did not contain bile: the subsequent operations might then have been avoided. Certainly it appears now that no harm would have resulted from doing so.

The after-treatment of the case has been described in some detail—to my mind it is the most important part of an abdominal operation in a child: to the diligence and skill with which Dr. Harwood carried out the details the successful issue of the case must be largely attributed.

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* Desrosiers, quoted by Moynihan in his latest edition of *Abdominal Operations*.

† *Keen's Surgery*, vol. iii, p. 994.

SIMPLE GOITRE AND ITS TREATMENT.

By F. N. G. STARR, Toronto.

By simple goitre I mean the type of thick neck so commonly seen. It is what one usually describes as an adenoma of the thyroid, though this has frequently gone on to degeneration and cyst formation. Sometimes these adenomata, situated on the superficial aspect of the gland, attain a great size without causing any discomfort, unless it be simply a sensation of weight. In other cases even a small enlargement, developing deep in the substance of the thyroid, may produce constantly-increasing dyspnœa by progressive compression of the trachea, or may bring about paralysis of the vocal cord and dilatation of the pupil on the same side by pressure on the neighbouring nerves—the recurrent laryngeal and the cervical sympathetic; while as a

Fig. 257.—The Incision, with Transverse Scratches made to indicate the Points of Approximation when Suturing.

result of lateral encroachment of the tumour, circulatory disturbances in the great vessels of the neck are likely to occur.

Some cases seek advice for one or more of the above reasons, others to rid themselves of an unsightly growth. Medical treatment is of no avail in dealing with these tumours; one must, therefore, have recourse to operative interference in all cases in which the enlargement is causing serious disturbance, or threatens to do so in the course of its development. Formerly, if a tumour was giving no trouble, I was in the habit of strongly urging that it be left alone, especially when cosmetic considerations only had prompted the patient to seek relief. Delay, however, aggravates the trouble, since these tumours usually continue to enlarge, and the result of operation is much more satisfactory when the tumour is small and the elasticity of the skin not

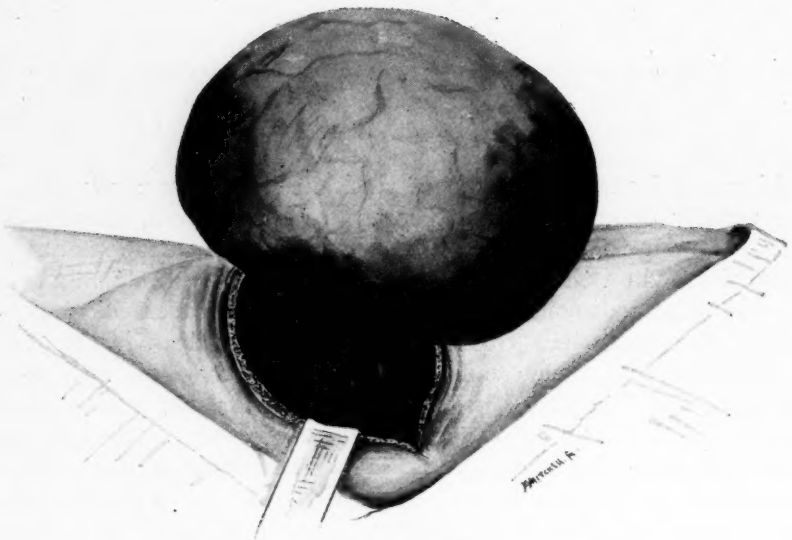

FIG. 258.—A LARGE CYSTIC ADENOMA DELIVERED.

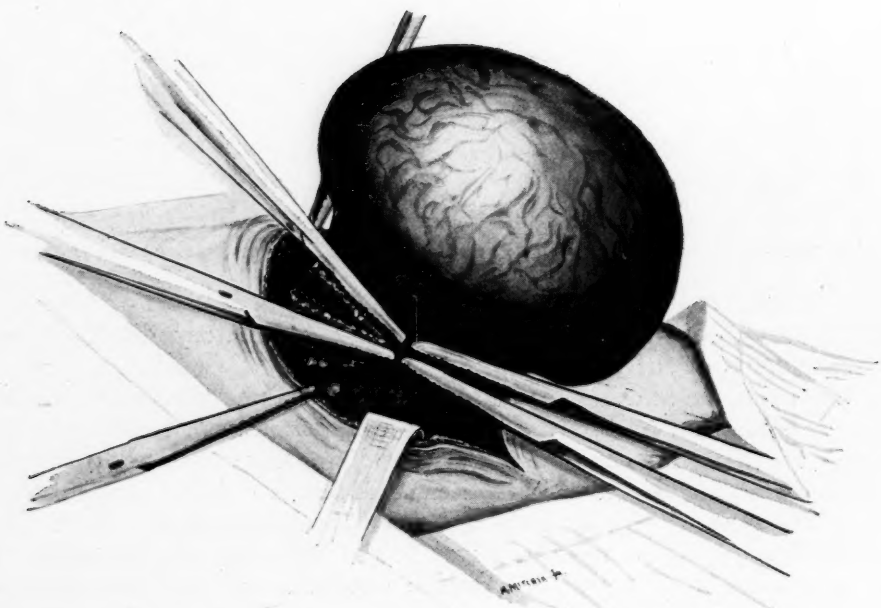

FIG. 259.—OCHSNER FORCEPS APPLIED TO THE PEDICLE.

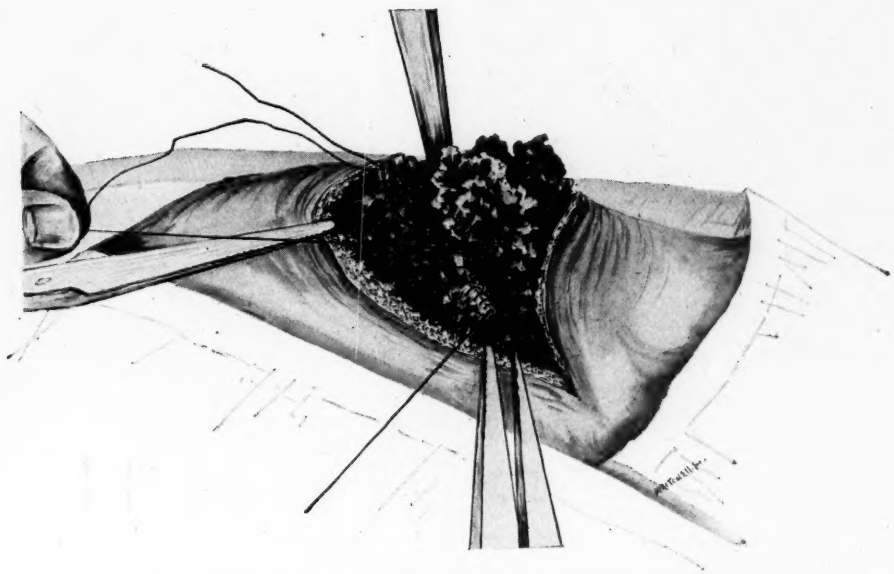

FIG. 260.—WITHDRAWING THE FORCEPS, AND PULLING THE SUTURE TIGHT.

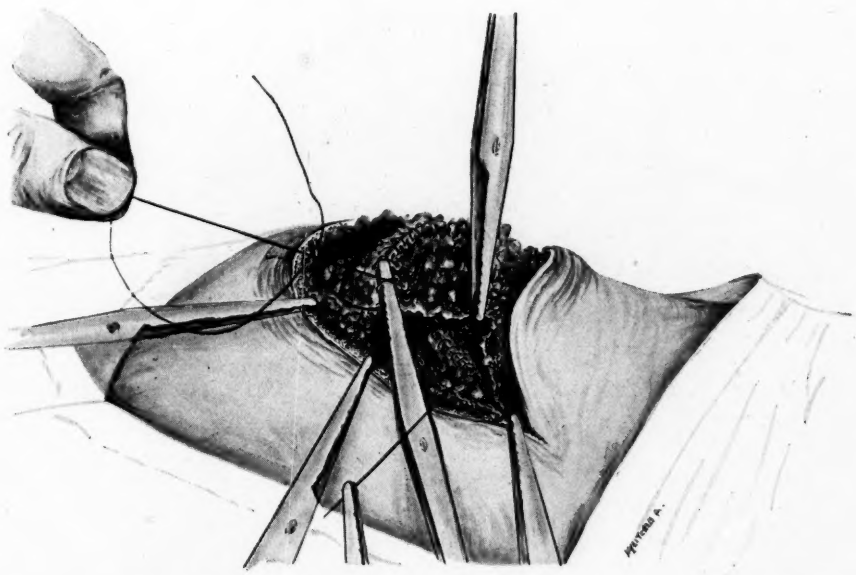

FIG. 261.—SUTURE RETURNING IN THE CAPSULE TO THE STARTING-POINT IN THE PEDICLE.

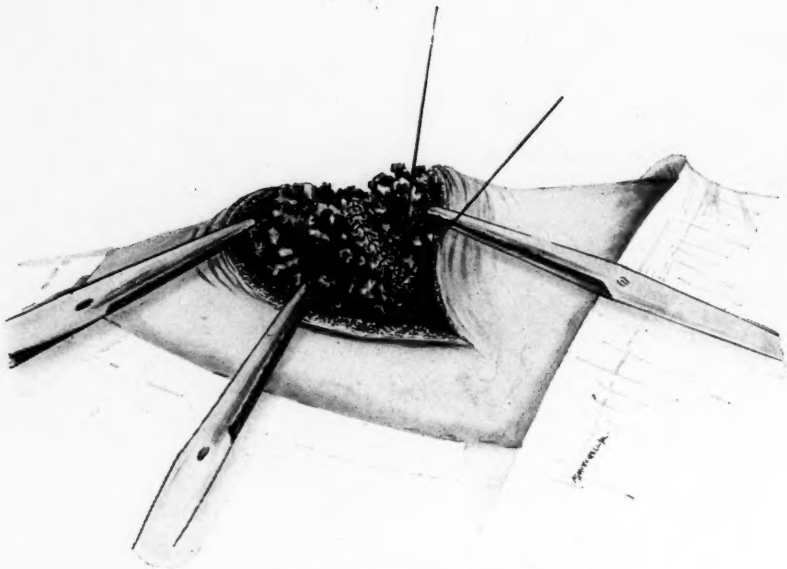

FIG. 262.—SUTURE OF THE CUT MUSCLES.

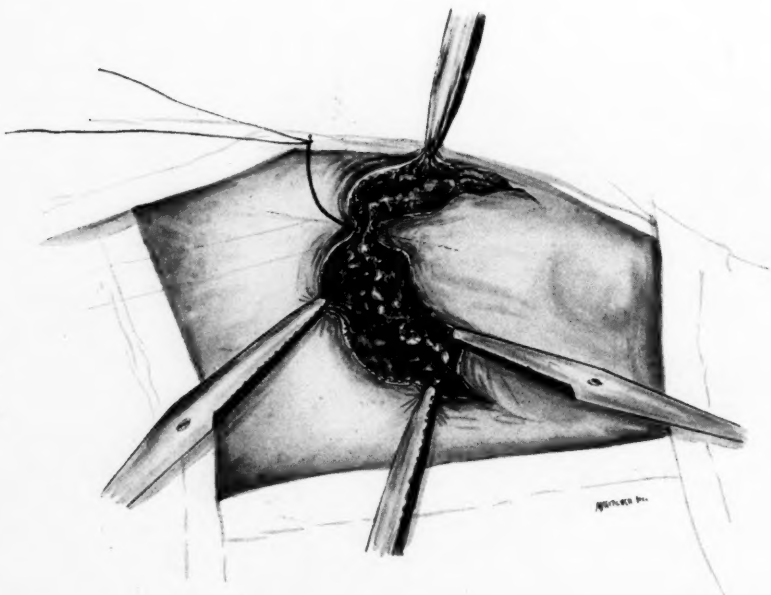

FIG. 263.—BEGINNING THE SUTURE OF THE PLATYSMA AT THE CENTRAL TRANSVERSE SCRATCH.

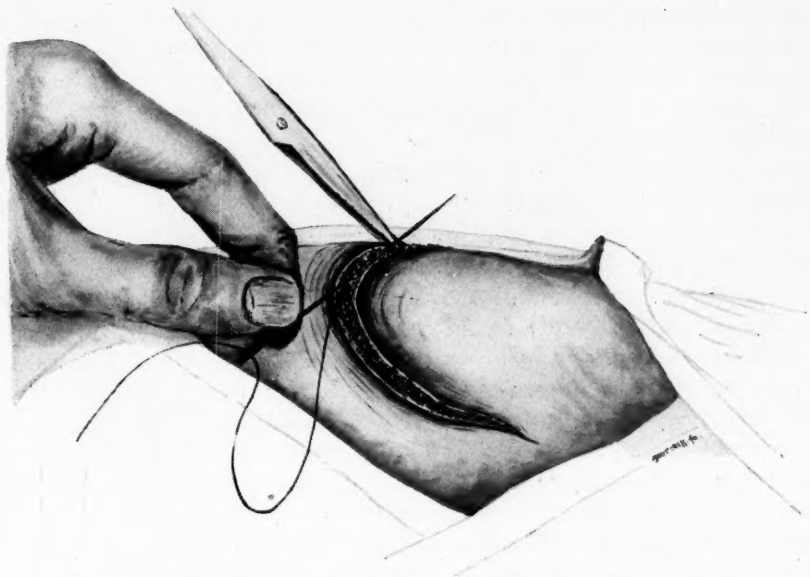

FIG. 264.—BEGINNING OF THE HORSE-HAIR SUB-CUTICULAR SUTURE.

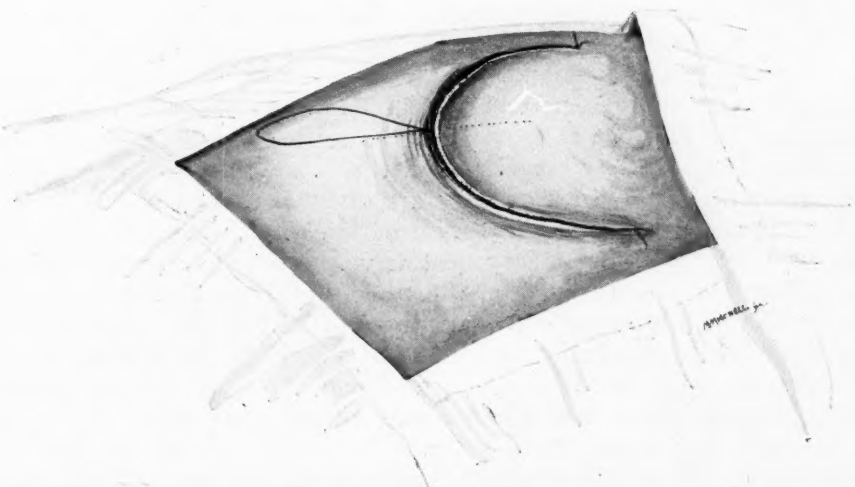

FIG. 265.—COMPLETION OF THE SUB-CUTICULAR SUTURE WITH A CENTRAL LOOP. When the knot at each angle is cut, the horse-hair may be withdrawn by the loop.

yet seriously impaired. Upon several occasions patients have returned with an enormously enlarged growth, the removal of which involved a hazardous operation; and more than once a patient has come back beseeching me to try to remove an unsightly scar, the result of some tyro's venture into surgery. Now, therefore, I usually advise removal even in early cases, for when the patient is in good physical condition, the operation, if carefully done, is practically without mortality, and rarely requires longer than a month for convalescence. Many, indeed, are able to resume their former occupations within a fortnight.

Operation. (*See Figs.* 257 to 265.)—The patient is placed on the table with the shoulders elevated and the head dropped back, so that the thyroid becomes conspicuous. I have found the collar incision most satisfactory, the extent of it depending largely upon the size of the growth. The anatomical mid-line of the neck, which may be displaced by a large tumour, is found, and the fascia uniting the right and left muscle-groups divided. If it is necessary to divide the sternohyoid and the sternothyroid muscles, this should be done between Ochsner forceps, which are used throughout the operation. They are applied as high up as possible, in order to give easier access to the upper pole of the gland. Then the superior thyroid vessels are secured, and divided between forceps. A hole is now made in the capsule anteriorly, two forceps are applied in the long axis of the lobe, and the capsule is divided between them until a sufficient opening is made to deliver the lobe in which the tumour had developed. Sometimes it is possible to bore through the gland tissue with the finger or with Mayo dissecting scissors, and enucleate a small single adenoma from the gland, securing any bleeding points as they appear usually, however, one finds not only the apparent enlargement, but a number of small growths as well, and in such cases it is wise to remove the whole lobe. The capsule is stripped from the gland laterally, and the larger emissary veins caught in their course in the capsule. If they bleed freely from the cut ends, where they issue from the gland, they are divided between forceps, one pair on the vein as it issues from the thyroid, the other securing the vein within the capsule. As the lobe is freed from the capsule behind, the branches of the inferior thyroid artery, issuing from the capsule at the lower pole, are caught as far as possible before they are divided. When one thus secures them on the glandular or inner surface of the surgical capsule, there is no danger of injuring the inferior laryngeal nerve. One must proceed with great caution, however, when the fascial capsule has been thinned out in this region by the inner pressure of the deeply-situated tumour. We continue to dissect from behind, gradually rolling the lobe over the trachea, until a comparatively narrow pedicle is secured; one pair of forceps is then applied to this pedicle from above, and another pair from below; when this has been done, the lobe may be safely cut away.

For suture, No. 2 iodized catgut, threaded on a curved intestinal needle, is used. Starting at the raw edge of the isthmus, the forceps clamping it are oversewn and withdrawn, and the suture is pulled quite snug by drawing up the loops. No knot is made, but the suture is kept taut, and continuing with the same thread, we ascend along the medial cut edge of the capsule, dealing

with the other forceps in like manner. In this way, all danger from hæmorrhage from the front of the trachea is avoided. We then surround with the same suture the forceps holding the stump of the superior thyroid artery, and from that point work down along the lateral cut edge of the capsule, securing all the bleeding points with this suture, and at the same time closing the capsule with a few stitches through both edges, thus leaving no raw gland surface in the neck. Finally we come to the starting-point, and the two ends are tied, leaving but *one knot* in the deeper layers. The muscles, if they have been divided, as is usually necessary, are sutured together, and then the deep fascia; it is now found that there is a perfectly dry wound, seldom requiring drainage (except in cases where the trachea has been thinned by pressure). The platysma is then sewn together, and lastly the skin edges by means of a subcuticular suture.

Graves's disease involves many vexed points as to whether, in any particular case, treatment should be medical or surgical, and it has not been considered here with the adenomata, for which only surgical measures afford means of relief. But the underlying principle of this operative procedure—use of the running suture—lends itself admirably to application in thyroidectomy for exophthalmic goitre. In that operation, as in all others where excessive vascularity and consequently profuse hæmorrhage from many points offers the leading technical difficulty, it is clearly of advantage to clamp tissues before they are divided. And after section, the running suture provides both for the large vascular channels and also for the troublesome field of oozing points. Thus are secured two prime requisites for healing with the least possible formation of scar tissue—a dry wound, and the reduction to a minimum of suture material, especially irritating knots. The elimination of endless ligaturing, the bane of operation in vascular areas, greatly reduces the time consumed. This is but another point in favour of the more widespread use of so simple and efficient a device as the running suture in the many fields of operative surgery where speed and easy control of hæmorrhage are matters of moment.

SOME OF THE SURGICAL USES OF CELLULOID:

TOGETHER WITH REMARKS ON THE TECHNIQUE OF FRACTURE OPERATIONS.

By G. S. THOMPSON, Sydney, Australia.

The present paper refers to certain uses of this valuable material which, judging by general practice, are not sufficiently recognized, and need emphasizing.

The celluloid generally used consists of sheets, varying in thickness from that of the ordinary photographic film, or less, to thick cardboard. In cases where it is desirable that a tissue-encapsuling investment should be provoked, the plate is perforated with punch holes throughout (*Fig.* 266), or wherever the infiltration is desired. The holes become filled with reactionary fibrous tissue, resulting from organization of the cellulo-plastic exudation provoked by their stimulation. Thus the improvised barrier ultimately consists of an intercalated foreign body invested in a fibrous or aponeurotic envelope, forming a thin

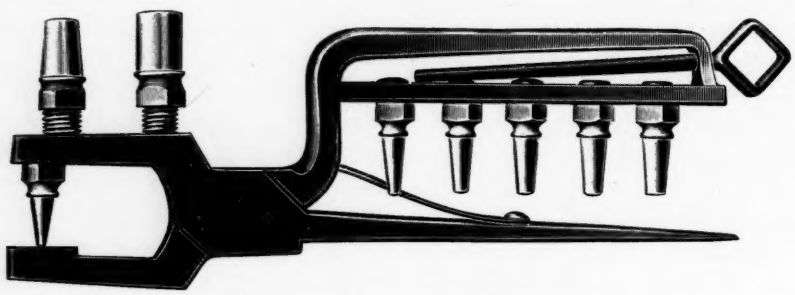

Fig. 266.—The Author's Punch
For piercing holes of various sizes in Celluloid Plates.

compound obstruction of great strength which at the same time does not interfere unfavourably with the neighbouring structures or the tissue requirements. Advantage can be taken of this fact, as already indicated, to round off a sharp border in the neighbourhood of structures which obviously might sustain serious damage by its presence. That a perforated piece of celluloid becomes rapidly infiltrated will be instantly proved if an endeavour be made to remove one. If for example an attempt be made at the end of forty-eight (or even twenty-four) hours—or still more, of a week—to extract from the orbital cavity a perforated celluloid globe inserted therein after excision of an eyeball, such an operation will only be effected with difficulty. Where fixity of this kind is not required, or such tissue formation would be harmful, the holes are omitted, or only placed in such parts, as along the peripheries, etc., where this particular object is required. Thus, infiltration can be made to serve the purposes of fixation, tissue formation, or to round off sharp edges. A plain,

smooth, unperforated plate of itself provokes little reaction. Indeed, where unperforated celluloid is used, the reaction caused is so slight as to give rise to the merest film of new tissue formation.

For application to certain parts of the body it may be necessary to mould celluloid to various shapes; this may be somewhat imperfectly effected by dry heat or boiling; but if crinkling or swelling is to be prevented, prolonged boiling must be avoided, as the consequent distortion in some places may be undesirable. So far I have been unable to find a good method of rendering celluloid temporarily and freely plastic, so as to enable it to be exactly and easily moulded into any shape whatever. The force of this disadvantage will be appreciated when its application in arthro-resection is considered later.

Sterilization is most conveniently and desirably carried out by boiling or the autoclave; if complete sterilization and asepsis are not obtained and maintained, sinus formation may ensue and even necessitate the removal of the celluloid. Absorption appears to be slight or nil, for plates used as long as three to four years ago in herniæ and in the skull still reveal no evidence of erosion, so that celluloid seems to be almost if not wholly unabsorbable—at any rate it remains for a considerable period in the tissues without appreciable change. If buried aseptically, it provokes no harmful reaction; the wound heals as well with as without it—in other words, by primary union. Nor does the plate afterwards cause inconvenience, or even remind the wearer of its presence; it becomes encapsuled like any other foreign body, and incorporated with the tissues, and being smooth, bacteria are retained by it with difficulty, whilst remote infection does not seem to occur. Thus the question of suppuration or sinus formation, apart from faulty technique, may be disregarded; inconvenience, damage, or danger to the parts does not occur, and consequently the apparent disadvantage of non-absorption is of no practical moment.

Practical Applications.—In the *British Medical Journal*[1] and the *South African Medical Journal*[2] I have called attention to the value of celluloid as the material of choice for filigrees in the treatment of the larger herniæ, such as require more than sac ligation; dealing more especially with the inguinal, femoral, umbilical, and post-operative varieties. In those articles both filigree and method are described, and, amongst other things, the superiority of a flexible substance such as celluloid over an inelastic metal is pointed out. The disadvantages and in some parts the dangers of wire, from its liability to erosion and fracture and its migratory nature, as well as from its undesirable chemical action, have been repeatedly demonstrated beyond question. *Fig.* 267 illustrates some of the ways in which this material may be usefully employed.

The *femoral filigree* consists of a triangular perforated celluloid plate provided with a flange on its outer border where this comes into relationship with the femoral vein.

The *inguinal plate* is roughly semi-elliptical, and rather larger than the space between the internal oblique and transversalis muscles and Poupart's ligament, having a gap at the outer angle or along the lower border for the passage of the cord. The border of this gap is either flanged, or perhaps better, the edge here is well riddled with punch-holes to determine infiltration,

so as to round off the undesirable sharp margin; by either device the cord is protected from a sharp border which might otherwise cut into and damage it. Originally the cord was carried to an aperture in the plate along a vertical slit; but this must be harmful by rigidly limiting the passage for the

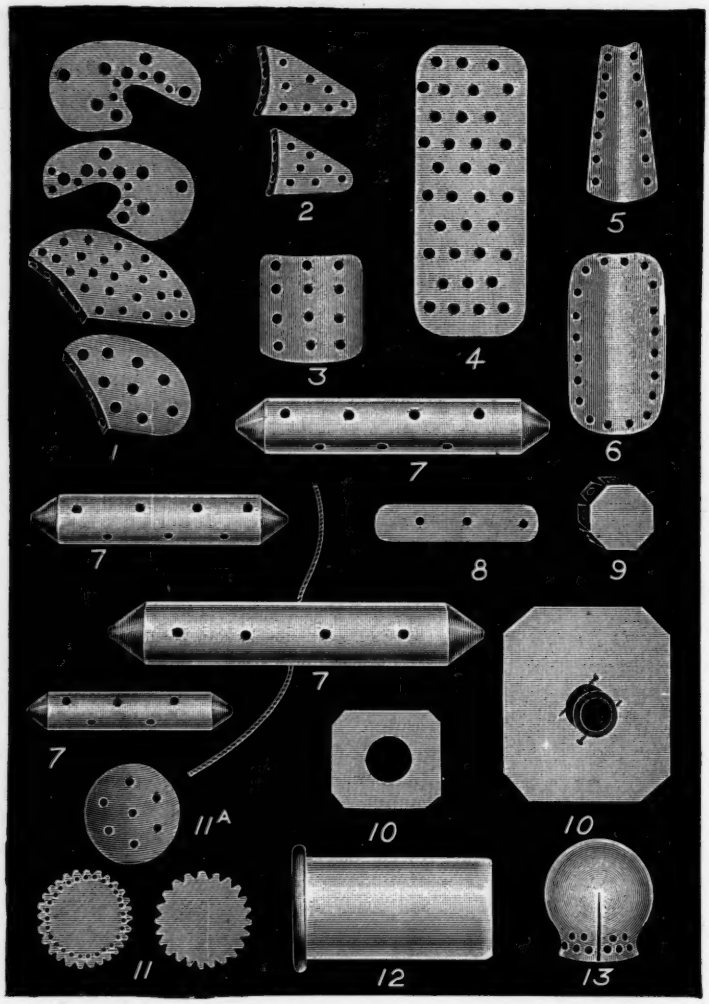

FIG. 267.—SAMPLES OF CELLULOID PREPARATIONS. (*About half scale.*)

1, Filigrees for inguinal hernia. 2, Ditto, femoral hernia. 3, Ditto, for umbilical hernia. 4, Ditto, for post-operative hernia. 5, Nasal bridge. 6, Bridge for spina bifida. 7, Celluloid pegs for bone fractures. 8, Celluloid plate. 9, Joint cap for covering bone in arthrodesis (rough representation). 10, Flanges for drainage tubes. 11, Skull plates (inner without perforation, except at edges). 11A, Skull plate (outer). 12, Dust-proof cover for surgical bottles. 13, Moulded cap for bone end.

cord, as well as hanging it on a sharp ledge, both of which effects might prove hurtful to this structure. I have accordingly modified the plate as above.

For *umbilical* and *post-operative herniæ* a suitably shaped perforated plate is all that is required.

In the *skull*, the thicker plates are useful to replace bone that is lost, or has to be removed for various reasons; one or more layers are fashioned to the shape of the aperture, the inner being placed flush with the internal table. Perforations are avoided, if possible, so far as the inner plate is concerned, except perhaps for a row of minute punctures just inside the margin to enable the plate to become fastened to the neighbouring bone by very slight infiltration (tissue-fibre threads—in other words, tissue suturing): a central aperture may be made if drainage be required. The reason for using an unperforated plate is the general undesirability of fibrous scarring after operations involving the brain membranes. Fine serration of the border might be an improvement, with a view to reducing to an inappreciable degree the slight anæmic necrosis caused by pressure on contiguous bone. If more than one plate be used, the outer one may be perforated, so as to still further fill out the space by ensuring new tissue formation.

Again, very thin sheets of celluloid (tissue sheets) prove useful to supplement lost or destroyed dura mater, or such as requires removal in consequence of trauma or disease; also possibly in brain surgery to prevent the formation or recurrence of adhesions, in place of the usual membranes, all of which are not only difficult of manipulation by reason of their softness, but some, like Cargile membrane, being absorbable, are likely to provoke rather than hinder such occurrences. It has been urged that fascia lata is preferable to celluloid in the surgery of the membranes. But fascia lata will provoke exuberant granulation-tissue formation, may necrose, and is not unlikely to be associated with suppuration. Such material would only cause extensive and dangerous adhesions, to say the least, apart from other more serious dangers, and is one of the worst things that could be used.

Celluloid will be found advisable in preference to other material such as transplanted bones—phalanges, pieces of rib, etc.—where the use of these is indicated in *plastic operations on the nose* for restoring the bridge, A strip can be inserted from the root or tip, subcutaneously, and buried. after separating the apposed tissues by a suitable elevator. Celluloid obviously is capable of producing a more artistic result, indeed I think a satisfactory one, which is more than can be said for the other crude procedures; moreover, it is not so liable to the necessity for removal for necrosis, with all its undesirable consequences, as in the other case. Film celluloid is of great value for inserting in the nasal cavity to prevent post-operative or recurrent adhesions.

I have been lately considering the possibility of *replacing the natural by a facsimile celluloid joint* in conditions calling for the present generally unsatisfactory operation of excision. By a special technique, to be experimentally tested, it is proposed to attach the artificial joint to the cut ends of the bones, after removal of the diseased joint by an open operation; the joint, it is hoped, will become fixed to these bones later on by osseous tissue: the object being to ensure a perfect reproduction of all movements previously impaired or arrested. In some cases anatomical limitations would confine the operation to one half of the joint, as in the temporo-mandibular, in which joint a suitable celluloid cap for the condyle, or a hollowed intra-articular disc, could be utilized with advantage to the individual, apart from the more elaborate technique referred to.

In some cases it may be desirable or necessary to improvise an adventitious *articular cover* for the raw bone at the time of operation. I would suggest tentatively that this might be effected by keeping a series of casts and moulders (*Fig.* 268), in different sizes, of the articular surfaces of the commoner joints involved. This moulder is divided into two halves, which are jointed together at the articular end. The celluloid is softened by heating, placed over the cast, and worked into shape by the moulder, which compresses the celluloid into the exact shape of the cast. The whole is fixed and then placed in cold water, and the bone cap allowed to harden. The cap is then slit upwards from the margin in two places, and removed (*Fig.* 267, *No.* 13); the margin is trimmed, riddled with punch holes, and inserted in a prepared space between the bone and periosteum, where it becomes fixed by osseous infiltration through the perforations. I believe there are great possibilities in joint work through the employment of celluloid, possibilities perhaps more hopeful than in any other direction, the only question being what is the most suitable means of adaptation and fixation to bone without causing pressure, atrophy, and loosening. Another way by which bones might possibly be provided with a smooth covering is by painting several layers of liquid celluloid over the raw ends. At any rate the scope for the employment of celluloid in this connection is full of promise in the surgery of joint resections, which at present is of the crudest, and a reproach to our art.

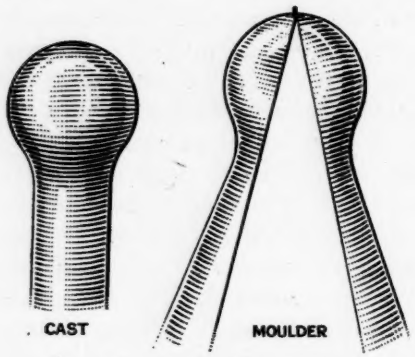

FIG. 268.—Diagram of author's suggested apparatus for the making of celluloid caps.

In regard to the use of *medullary pegs* for fractures, some time ago I had made eight celluloid rods one yard long, varying in diameter from one-sixteenth to half an inch in gradations of one-sixteenth of an inch. The rods are cut into lengths varying from two to four inches, according to the size of the bone concerned. An important advantage of the celluloid peg is that it is not brittle, and it possesses a very slight resiliency which is desirable where the strain to which large bones are naturally subject is considerable; it is therefore not liable to snap if ordinary precautions are observed. The ends of the peg are pointed, the rest of it being drilled at intervals throughout its length, transversely and in different diameters. By means of a cord inserted through the central transverse canal (as shown in *Fig.* 267, *No.* 7), and made of chromicized catgut or Japanese silk, the peg, after being partly or completely buried in the shaft of one fragment, and after the alinement of the two fragments has been effected, can be drawn into position so as to be equally shared by the two fragments. This plan of treating fractures has many obvious advantages, not the least amongst others—as emphasized by Mr. Hey Groves—being perfect alinement; permanent immobilization; non-interference with the osteogenetic tissues and periosteum, and therefore the improbability of non-union; slight disturbance of the parts,

and therefore a minimum of time-consuming efforts, with all the advantages thereby entailed.

At the time I devised these celluloid pegs, an article by Mr. Groves, which will well repay perusal, appeared in the *British Medical Journal*, bearing on the same subject. I must acknowledge my indebtedness to Mr. Groves for one or two points which I have incorporated in my pegs. I notice that after trial of numerous substances for direct fixation, he prefers metallic pegs because of their strength, but perhaps he is not aware of the capability of celluloid to stand a heavy strain. I must confess to a strong prejudice against the use of any metallic material in the body wherever it can be avoided. Such substances—apart perhaps from duralumin—are liable to chemical and electrolytic action, fracture, migration, unsuitable tissue adaptation, etc., and are therefore inferior to specially prepared celluloid. Bone will be found useful, and can be readily improvised and shaped from an ordinary tooth-brush handle, from which article also celluloid may be obtained. Bone, however, is too brittle, and relatively weak, a point which is important in the case of the larger bones, which are subject to considerable strain. Ivory is another substance that might be mentioned, but its cost is prohibitive, its hardness makes it difficult to work, and perhaps its brittleness might render it liable to snap. The perforation of the pegs, which Mr. Groves does not practise, helps to secure rapid and certain fixation by infiltration; the holes, in conjunction with the guiding thread, prevent any possibility of displacement. Later, the canals probably become permeated by endosteal bone which replaces the fibrous strands (osseous suturing).

As regards the tissues, it will be found that a sterile celluloid peg remains *in situ* indefinitely without the patient experiencing any discomfort, disability, of consciousness of the presence of a foreign body, and that the material becomes incorporated with the parts; this is a legitimate deduction from some years' experience of embedding this substance, and from the experimental evidence in connection with intramedullary pegging.

The medullary peg method possesses advantages in the relatively small incision required, the slight exposure necessitated, the trifling amount of manipulation of and injury to the tissues, and therefore the reduction of mechanical trauma to a minimum, the rapidity and ease of operation, the absence of any mauling or gross derangement of the periosteum, and the perfect and fixed alinement. Absent or defective union, displacement, operative or frictional sepsis, and imperfect functional results are thus avoided. These facts have been practically demonstrated by Mr. Groves's experiments on animals, and might indeed be anticipated on theoretical grounds. Medullary pegs or internal splints effect and maintain apposition and fixity, whereas wires, screws, plates, etc., by themselves cannot do this, owing to the pressure-absorption produced by the wires and screws whenever applied firmly enough to effect their object; the anæmia and molecular atrophy which pressure entails give rise to the phenomenon of anæmic necrosis so well known in pathology. The alleged defects of pegs in my opinion do not exist, and granted a correct technique, gratifying results may be anticipated. I believe this method is destined to supersede the others; it is certainly more rational, and takes due cognizance of tissue requirements and essentials.

If a foreign body is smooth, devoid of irritant properties, sterile, and if it is inserted under aseptic conditions, with the least possible damage or tension to the tissues, the prospect of future trouble is so small that it may be disregarded. Most foreign bodies that cause trouble, silk for instance, or wires and plates, involve friction or are rough and irritating, and so become infected. I agree with Mr. Groves that many cases of fracture sepsis are almost solely the result of irritation due to movement, the consequence of bad and inefficient methods of fixation. This is a most important observation, and unless its significance be realized and applied, and the causative factor removed, we shall continue to place the blame in the wrong place. We must avoid jagged bodies, unsuitably applied, and eliminate movements of the bone fragments.

It has been suggested that when the medullary peg principle is practised in the case of fractures, autogenous bone-grafts are preferable to foreign substances. If, however, celluloid, for instance, produces no adverse after-effects —it being again emphasized that this method considerably reduces the likelihood of sepsis—then the matter of non-absorption has merely an academic interest. Again, bone-grafts involve a mutilating operation on another bone, with the attendant risks. It is difficult, and takes time, to cut out the correct size and length, and much damaging trimming is necessary to correctly adapt the graft to the medullary canal concerned. Such manipulation damages the graft and offers every chance for its infection.

When one remembers this, and that we are dealing with a poorly nourished tissue like bone detached from its blood-supply, and when one considers its impaired resistance under these circumstances, its solid consistence rendered the greater by intracanalicular thrombosis, thus rendering it partly if not completely impermeable to the nutritive fluids necessary to maintain it alive—when, I say, these conditions are borne in mind, one realizes how likely suppuration is to occur.

But even though suppuration be averted, injury and malnutrition alone are only too prone to cause the death of the graft, which then acts merely as a foreign body, and a scaffolding for endosteal osteogenesis; the graft will then be replaced by another formed *in situ*, to attain which we must run very serious risks. We could obtain the same result, without the risks, by prepared heterogenous bone-pegs; but even these are no better than weak absorbable foreign bodies, and, if impregnated with antiseptics, would be irritating.

If we bear in mind the method of acquiring and elaborating autogenous grafts, it is almost certain that no thick graft could be kept alive by imbibition from intramedullary exudation long enough for vascularization to ensue. I think there can be no doubt that the two factors, bone plus clot, offer an effective barrier to the nutriment necessary to preserve the vitality of the graft. Add to this the severe trauma and perhaps sepsis acquired by it in its elaboration, and one can realize with what anxiety such an operation would be followed. Disaster would be the rule, a good result exceptional. For these reasons I think one is justified in saying that even an uninfected autogenous bone-graft, particularly if large, is a virtual foreign body capable of absorption owing to aseptic necrosis, and that such at least is its usual fate. To obtain and use a bone-graft, and probably a badly fitting one, is to run the grave

danger of inviting sepsis, as well as the risk of fracture owing to the serious defect of frangibility, a contingency all the more likely in the case of a loose fit; for it would be difficult to shape the graft to fit as well as a celluloid peg selected from a specially prepared graduated series. To undertake autogenous bone-grafting, for a result which only exceptionally could be satisfactory, is to take a risk that involves a prolonged antecedent mutilation, not free from immediate and remote dangers, in order to obtain a graft usually unsatisfactory in length, shape, and strength, which may suppurate, snap, or necrose; this risk is one which to my mind is altogether unwarrantable.

During the discussion on fractures at the recent South African Medical Congress (July, 1914), I contrasted the advantages of celluloid pegs with the faults of the various metallic devices. The opener of the discussion, who evidently misunderstood what I had said, stated that he did not favour pegs, and claimed that wires and screws did not become loose, apart from septic infection; also that there would be difficulty in extracting pegs should suppuration supervene. I will deal with these three points seriatim: (1) Suppuration; (2) Aseptic loosening of metallic structures; and (3) The supposed disadvantages of these and other pegs.

1. *Suppuration.*—If suppuration were common in cases of operation for simple fracture, the justifiability of this plan of treatment would at once disappear. But it is the exception, and in any case is not an argument against this technique, but a very strong one against anything which invites infection, and for the adoption of proper means of avoiding it. At the present time infection is still too frequent, and further, one may assume that it is an avoidable and therefore unnecessary complication, which will soon become a just reproach to the surgeon. We may not be able to avoid it in every case, but I suggest that the following points in technique might go some way in reducing or even abolishing it.

i. Operative delay for three to seven days, to allow of local absorption and repair of damaged tissues. This can be hastened by massage, cold or evaporating applications, and by elevation of the foot of the bed in the case of fractures of the lower limbs. By these means the local resistance of the soft parts is increased, and a more favourable state of tissue for repair and resistance is produced than can prevail by operating on recently damaged and devitalized parts. Contracture in this period can and must be guarded against by counter-extension.

ii. Dry preparation of the skin, and avoidance of antiseptic compresses or moisture-retaining protective material like oiled silk, gutta-percha tissue, etc. The skin is cleansed by ether soap, turpentine or petrol and ether, minus the use of the time-honoured nail-brush (which only damages the skin); then, perhaps, painted with tincture of iodine, which is allowed to dry; after that, dusted with sterile talc powder and covered with a dry sterile cloth, which is bandaged on; no further preparation is required even on the operating table. At the end of the operation the skin is merely dusted with a thick layer of talc powder and covered with a sterile unmedicated dressing. In passing, one might also emphasize the importance, when shaving the skin, of conducting this operation with the greatest care to avoid any cutting or abrasion thereof —a prolific source of infection.

iii. Dry gloving of hands, so that if puncture of the gloves by sharp spicules of bone occurs, as is so likely in these operations, there shall be no moisture-laden nidus to favour the growth of micro-organisms and permit contamination of the wound, which has been proved to occur despite the exhibition of antiseptics; the gloves are sterilized by dry heat, the hands, after preparation, dusted with sterilized talc powder (e.g., Colgate's) and easily inserted into the dry gloves; these must be touched by no one, but held in a sterile towel—a method in every way superior to the ordinary one.

FIG. 269.—Author's spring towel clip.

iv. A skin-free wound, obtained by completely investing the limb in a sterile cloth before the operation is commenced, so that no neighbouring skin can be seen or touched during the operation, and, after the cloths and skin have been incised, by tucking the former round the edges of the latter and retaining them there by Michel clips, my special watch-spring towel clips (Mayer & Meltzer, *Fig.* 269), or by suture.

v. The avoidance of antiseptics, with their tissue-damaging and resistance-lowering actions, and the substitution of the aseptic method, the wound not even being flushed by saline solution, but merely cleansed by gently wiping with a sterile swab. It is highly probable, if not certain, that much of the trouble and uncertainty arising in connection with clean wounds, and bone operations in particular, can be explained by the damage inflicted by antiseptics. Not only do these damage tissue, and so interfere with repair and favour infection, but in the case of bone they may be a potent factor in the production of non-union—which is so relatively common in simple fractures after operation—by the injury thus inflicted on the osteogenetic tissue. This applies to clean wounds, and possibly also to infected bone conditions such as compound fractures and osteomyelitis; in the last case, particularly, it is possible that the use of very potent antiseptics (e.g., caustics) may increase already existing necrosis or even produce it. This, however, is a point that still needs experimental investigation. Antiseptics may perhaps be permissible here in the absence of something better, even by a consistent aseptic surgeon, if they can be so regulated as to produce less damage than the virus.

vi. The use of pegs, to obviate the necessity for extensive incisions, manipulations, and consequent damage inflicted by the ordinary procedures, and to ensure the other advantages previously mentioned: all tending to reduce or abolish suppuration. This is one amongst many other reasons for the use of pegs in preference to wires and screws.

vii. The use of the tourniquet—an important time- and damage-reducing factor; the fear of subsequent oozing being negligible compared with the infinitely greater counter-advantages.

viii. Where applicable, the use of Bier's bandage at a suitable time after operation.

Where the above points of technique are faithfully carried out, we may look forward with confidence, not only to primary union, but also to the more rapid and effective attainment of the object of the operation—a perfect anatomical and functional result.

2. *Loosening of Wires, Screws, etc., apart from Sepsis.*—I am afraid this

is a fact, and indisputable. A wire, even though fixed quite tightly and the apposition of the fragments rigidly effected at the operation, loosens later and allows movement at the site of fracture, this being due to the well-known phenomenon, already mentioned, of pressure atrophy, arising from the grip of the metal on contiguous bone. The wire cuts slowly but surely into the bone towards the line of fracture; in the same way the screw causes atrophy of the osseous thread, it becomes loose, and is ultimately so free that it can with the greatest ease be lifted out of its bed. That gross displacement does not more often occur in these cases (for it does happen occasionally) is probably due not to any inherent excellence of the method, but to the protection afforded by the external splinting, which is nearly always used to supplement the internal faulty method; and it can only be affirmed that the above phenomenon is a fact despite any assertion to the contrary. The slighter movements and resulting ill-consequences (the worst and most frequent being induced sepsis) occurring at the seat of fractures treated by metallic structures are well shown in the illustrations in Groves's paper and pamphlet. The loosening defect could be partly overcome in the case of screws by having them transversely drilled to allow of tissue infiltration, which would in some degree make up for the loss of grip due to atrophy; and I would suggest to those who use them, that all screws for fractures be transversely perforated, as in my pegs, with this end in view; bone-plates might also with advantage be provided with a few smaller perforations in addition to the screw holes, but not so many as to weaken the plates.

3. *The Disadvantages of Pegs in the Presence of Suppuration.*—These would apply with greater force to screws, wires, etc., owing to the likelihood of sepsis; in either case the foreign body must be removed, and one is no worse off in the former case than the latter. With the peg it will merely be necessary to cut it across at the middle, and the extraction of the two halves is comparatively easy. But suppuration with the peg technique being unlikely, the necessity for any such operation later on would be rare indeed. If, however, such a contingency should arise—if, after giving a fair period for spontaneous cure, discharge still continues—operation must not be delayed too long; otherwise excessive fibrous-tissue formation would make extraction somewhat difficult; but this of course applies to any foreign body and is not peculiar to pegs. This criticism is therefore an argument against sepsis, not against the use of pegs.

As a material for *transfixion pegs*, celluloid, in the form of solid or canalized rods, suggests itself in place of ivory; and canalized celluloid discs should prove useful as bone grafts to span intervals of bony deficiencies.

Celluloid may also prove of value as a *collar*, or *bone plate*. The former, however, whether of wire, metallic plates, or other material, is very unsatisfactory for fixing fractures. It fails to immobilize the parts securely unless great pressure is used to fix them, and this *per se* causes undue injury to the parts. Whether placed outside or beneath the periosteum, it interferes with the blood-supply and osteogenesis, thereby favouring non-union, in the former case by pressure on the vessels in the periosteum, in the latter by severing the small vessels connecting periosteum to bone. Moreover, this avascularization induces atrophy, and therefore loosens the grip of the collar;

it favours mobilization of the fragments, and injurious mechanical friction follows at the line of fracture, inviting exudation, tension, and infection. The collar is a distinctly unfavourable form of foreign body, and should be given up.

For *filling bone cavities*, a honeycomb spongework of celluloid offers a favourable solution of a difficult problem.

I suggest film sheet-celluloid as the material of choice to *replace periosteum* which has been damaged or is defective, as in the condition of traumatic ossifying myositis, for which the use of fascia has been recommended in order to confine the osteogenetic cells to their proper sphere.

The value of celluloid as a light *splinting material* for the fingers, limbs, etc., is now becoming recognized; attention may well be given to its similar use in spinal caries. Further, in place of immobilizing the spine by luxation and fixation of the spinous processes, the same thing may be accomplished more easily and with less mutilation by means of a buried celluloid bridge. Splints for all sorts of deformities and defects are now placed on the market by Longmate, of Weymouth Street, London.

Celluloid might be employed as an *obturator* in the mouth, either free or buried, after removal of the upper or lower jaw. In operations on the frontal sinus, a celluloid mould might be adapted later on to facilitate the complete removal of the orbital ridge and ensure more rapid closure of the wound—plastic relief being afforded later on by a suitable celluloid plate to replace the natural bony prominence.

Spina bifida is a condition in which an ideal closure of the gap can be made by a properly shaped celluloid plate provided with peripheral perforations to ensure anchorage along the border. The increase in the size of the gap with the growth of the individual tends to straighten the plate and draw out a layer of tissue from the margin of the spinal deficiency. This method is superior to the prevailing plastic mutilations, such as bone and muscle mobilization, etc.—passing over, of course, such a barbarous procedure as injection of iodine. I have never seen this plan advocated for spina bifida, yet I think that without a doubt it will be found superior to any other form of treatment. In this connection one might urge the desirability of not puncturing the structure itself in the process of emptying the often dangerously distended, attenuated, and inflamed sac. This is often done and recommended; but it is safer to insert the needle into the spinal canal above the sac and through healthy tissues, thus relieving the tension indirectly. The flaccid sac wall may then be painted with tincture of iodine, and, when the latter has dried, dressed with a thick layer of sterile talc powder. Tapping through an inflamed sac is only calculated to invite septic disaster. The operation for closure of the gap will take place later on when the parts are quite healthy.

After excision of the eyeball, *celluloid spheres*, either perforated or intact, should be used to the exclusion of metal or glass.

Lastly, instead of the specially prepared empyema tubes furnished with rubber flanges to regulate their depth, a very convenient and inexpensive *shield* can be made quickly by punching a hole, rather less than the diameter of the requisite tube, in a piece of celluloid. The tube is thus grasped

tightly by the celluloid; but as a precaution, the wall of the tube on one or both sides is transfixed by a pin, which is then cut short: this effectually prevents the tube slipping out of the flange (*Fig.* 267, *No.* 10). The same device will avail elsewhere to retain tubes in position and prevent them escaping into cavities, and is also very convenient where it is desired to connect a drainage tube to some suction or siphonage apparatus, as in recent methods of treating empyemata, liver abscesses, etc.

The above are but some of the innumerable uses to which this valuable product can be put; others will naturally suggest themselves to surgeons, and it is with the object of directing attention to this valuable and somewhat neglected part of the surgeon's armamentarium that I have ventured to offer these scrappy remarks.

A flame-proof celluloid known as 'Taxuloid' is now placed on the market; apparently it owes this feature to the presence of calcium.

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GUNSHOT WOUNDS OF THE CRANIUM: WITH SPECIAL REFERENCE TO THOSE OF THE BRAIN.

By Captain R. WHITAKER, R.A.M.C. (T.C.)

It is not possible at the present moment to obtain a complete account of the subject of gunshot wounds of the brain, because the conditions of transport and environment, and the period between injury and treatment, differ so much in the various areas of the campaign. A complete knowledge of the matter can only be gained by each observer making a record of the facts within his own experience and the conditions under which they were observed, and by a final putting together of pictures from different points of view in order to obtain a true perspective. The last must remain for the future.

The time which has elapsed before treatment is undertaken is perhaps the most important condition which modifies results. Thus, the history of the clearing and dressing stations will tell of the high mortality from direct cerebral injury. The history of the base hospital which receives its cases within two days of injury, will indicate the success which attends the prevention or obviation of primary sepsis. The general hospital which receives patients seven or ten days after injury and keeps them till convalescence, can record the results not only of trauma, but also of sepsis, and can speak with some certainty of the mortality of the cases which survive the first injury. Lastly, some special investigation will be required with regard to the ultimate fate of the survivors, of their functional capacities, and of their mental condition.

The present communication is an attempt to give all the salient facts of a complete series of cases which for the most part were received from seven to ten days after injury and kept under observation for one to three months. Excluding all merely extra-cranial injuries, my list deals with 106 cases of gunshot wounds of the cranium; of these, in 88 the lesion was a penetrating or perforating wound of the brain, i.e., it was intradural. It is mainly with the latter group that we are concerned.

The original operative treatment of gunshot wounds of the brain advocated and adopted by Sir Victor Horsley is the basis upon which the treatment of these cases has been founded. It is as follows:—

1. The injured and septic area of scalp must be freely excised.
2. The injured area of skull must be freely exposed by suitable incisions and the turning down of suitable flaps.
3. Normal dura mater must be freely exposed around the entire circumference of the wound which penetrates it, by a wide removal of bone.
4. Foreign bodies, blood, and pus must be removed from the brain without breaking down protective adhesions.
5. The whole wound must be left open from the first.

This treatment in the case of a small gutter fracture is of course an extremely simple procedure.

The Factor of Decompression.—In cases where the bullet has perforated the brain, the wounds of entry and exit are both treated in the way described. This leads to the exposure of a large area of skull, perforated by two holes, in which lies the wounded dura mater. If the wounds of entry and exit be close together, the inevitable joining of the original two openings into one leads to the appreciation of a new factor in the treatment of these cases—that of decompression.

It very soon became apparent that the cases in which the bony wounds of entry and exit were so near together that the requisite removal of the bone around them threw them into one, did much better than those in which, owing to their situation, the wounds of entry and exit were dealt with separately—that is, the more freely decompressed cases did best.

Again, in this type of case, two other facts were observed in the later stages:—

1. The cerebral herniæ, that are of course the inevitable sequence of injuries such as these, were relatively smaller than in any other type of case. This, as I am satisfied now, and as I think *Case* **73** serves to illustrate well, is due to the fact that the sound dura mater does to a very appreciable extent bulge through the bony opening, and so relieves the intradural tension. In other words, it yields somewhat to the pressure. But although the dura is certainly capable of being stretched, it is not elastic, i.e., it does not resume its original area when the tension upon it is relieved, but merely sags in the wound.

2. The herniæ which formed did not become strangulated and did not slough, but retired ultimately entirely inside the dura mater, which in the end became slightly concave.

I am satisfied that the element of decompression is as important as the actual treatment of the brain injury. As my experience increases, I am inclined to deal more, rather than less, drastically with these cases so far as the bony cranium is concerned. I have often been surprised at the swift and uneventful recovery of cases in which the injury appeared hopeless, and where a really enormous decompression was done *faute de mieux*, because the fracture radiated in all directions, and great sheets of bone were found loose in the wound.

The Search for Foreign Bodies.—I have deliberately used the phrase 'as important as the actual treatment of the brain injury,' because, while the wound in the brain is always thoroughly explored, and all fragments of bone, foreign bodies, etc., which are obvious are removed, it is clear that the preservation of the patient's life does not depend to any material extent upon the removal of some small fragments which may have been overlooked. The brain is an organ which is far more able to take care of itself in this direction, far more resistant both to mechanical irritation and to sepsis, than one's first impressions would lead one to believe.

Many of the cases which follow, while well on in an uneventful convalescence, have thrown out one or more small pieces of bone from a dimple that appears in the centre of the shrinking cerebral hernia. Also several

of them have gone to England or Australia with bullets, revealed by the *x*-rays, in inaccessible portions of their brains, the patients being apparently mentally and physically normal. I am satisfied that the patient's interests are not best served by a prolonged search for fragments in his lacerated brain, or by very persevering efforts to grasp some elusive small foreign body that may be felt deep in the wound.

One of the first things I learnt in connection with these cases was that the *length of time* taken over the operations was of paramount importance. Most of the patients were desperately ill on arrival, and prolonged manipulations of any sort, no matter how desirable in theory, were in practice foredoomed to a fatal termination. Throughout these operations the dominant note must be speed—speed and free decompression. The brain itself is able to deal with small foreign bodies left in its substance, provided always that it be given room through which to do so.

It has been pointed out to me that possibly these statements, through misinterpretation, might be regarded as dangerous. I realize fully that in theory it is essential to remove every atom of foreign matter in the brain, and every portion of the surrounding brain substance which has been in contact with and become infected by these fragments, if the patient is to have his best chance of complete recovery. Nevertheless, from purely practical considerations, I would uphold the method of treatment described above. The following conditions are necessary for the complete and safe removal of all foreign bodies: Perfect *x*-ray pictures; a correct interpretation of them; a knowledge of the nature and extent of the infection; such a condition of the patient as will permit of the delay required by these observations; and a perfect equipment and environment. It is rare for even the majority of these conditions to be obtained; and in the present series, although we had an excellent equipment and environment, yet the worst cases came in in groups of several at a time, together with other serious cases which required attention; *x*-ray pictures were seldom available within the first few hours of admission; and many of our cases presented signs of such urgent gravity that nothing justified delay in operation.

From a practical point of view it is better to act as suggested; to get the patient safely off the operation table, and through a convalescence which is stormy and anxious—watching, it may be, the extrusion of several pieces of bone from his cerebral hernia; and finally, to wish him well as he starts for home;—rather than to do an operation which the pathologist, noting that no bone, metal, or hair has been found by him in the brain at the autopsy, can certify was complete.

The Dominant Importance of the Nature of the Infection.—Many preconceived ideas on injuries to the brain fall to the ground after the examination of a series such as is given here. My feeling now is that no brain injury, however apparently hopeless, is necessarily fatal. The dominant factor in them seems to be the nature of the infection rather than the extent of the trauma. Reference to the table of statistics will reveal that a streptococcic infection is followed by a mortality of over 90 per cent; and even as I have often been surprised at the recovery of a man whose local injury was apparently hopeless but in whom infection was *Staphylococcus aureus* or *albus*, so have I lost men

with very small gutter fractures, and relatively most trivial dural laceration, in whom the infection was streptococcic. The victims of the former infections, when efficiently treated, put up an amazing fight; and their defeat, if they be defeated, is in my experience practically always due to the invasion of their ventricles and a subsequent spreading basal meningitis; a reference to the post-mortem reports will reveal that in all of them the local condition is satisfactory, in that firm adhesions between the pia arachnoid and dura and skull are present—in other words, that the infected portion of the brain is shut off from the surrounding areas. In the streptococcic cases the reverse of this is seen; no adhesions, or only very feeble ones, being found.

Clinically, the cases can be diagnosed from each other within a very short time. In the former group, the patient may be paralytic, he may have fits, severe cerebral vomiting, be maniacal, or comatose; but his cerebral hernia, no matter what its size, from the first shows efforts at self-protection, in the shape of a rapidly forming, smooth, and glossy surface-membrane that remains unruptured—save for the extrusion of the before-mentioned pieces of bone sometimes left behind at the operation—until it commences to shrink. In the streptococcic cases, the hernia grows with a horrible rapidity, and none of these local signs are seen. The patient may of course exhibit any of the signs described in connection with the other type, but is usually somnolent or comatose. At the autopsy, which is held within a few hours or days after the operation, no attempt at local protection is found, meningitis spreading directly from the injured area is present, and the neighbouring brain substance for a large distance is necrotic and semi-fluid; the ventricles may or may not be invaded, but their involvement, when present, appears rather as a secondary than as the primary factor in the patient's death, when the evidence of pathological change starting from the original injury and spreading therefrom without any attempt at localization, is considered.

The autopsies on non-streptococcic cases which die with ventricular invasion, show that the latter has taken place through a very narrow track, situated where the wound in the brain is deepest or the ventricle nearest to the surface. In other words, the infection has overcome the resistance in its weakest spot, rather than advanced unchecked in all directions.

Technique Employed.—All these cases have been given chloroform and oxygen. From the very early days, I arranged with the anæsthetist that he should warn me fifteen minutes from the start of the operation, and decided that the patient should invariably be off the table at the end of twenty minutes. After a reasonable amount of experience, there is no difficulty in completing even the most extensive of these operations without over-stepping this time-limit.

The whole scalp is shaved, washed with petrol, with methylated spirit, and then with iodine. After excision of the septic wound or wounds, suitable incisions are made, and scalp flaps turned down to expose the area of skull to be dealt with, on a scale which allows for the fact that in almost every case more damage is found and more has to be done than was anticipated. So far as the saving of the patient's life is concerned, the scalp incision employed is of course a minor matter. It has, however, a distinct bearing upon his later convalescence, and possibly upon the question of further

after-treatment. I do not think the formation of a flap should be regarded as an essential part of the operative exposure in every case. What is essential is free exposure of the injured area of skull and brain, and in general terms it may be stated that this is best obtained by a flap in the simpler cases, or by irregular incisions in the more complicated. If large flaps be added to the open wounds in the latter case, it will involve an addition to the duration of the operation, and to the suffering during convalescence, which it is here particularly important to avoid. *Case* 76 is an illustration of this type.

From the moment the operation is started, the whole wound area is kept under continuous irrigation with 1–40 carbolic. The flap, if a flap incision has been used, is grasped at its base by an intestinal clamp. Vessels on the concave side are seized with pressure forceps. These, and others that may have to be applied to the flap at the end of the operation when the clamp is removed, are left *in situ*, and taken off twenty-four hours later. Tying or suturing vessels in the scalp is a difficult and uncertain business, and the time occupied in its performance, and the additional loss of blood it may involve, in my opinion add gravely to the operative risk. I never ligature or suture vessels in these cases.

Bleeding vessels in the brain or dura, and the great sinuses when wounded, are dealt with by muscle-grafting. The control of hæmorrhage from a big sinus, when done by gauze packing, is a never-ending source of anxiety and annoyance. A piece of muscle or fascia taken from the wound, held by an assistant over the bleeding vessel, with the intervention of a smooth rubber glove or dam for a very short time, while the operation is continued, will control any hæmorrhage from the brain or its coverings. I have muscle-grafted several of the great sinuses many times in this series of cases, and the ease with which it is done, and the efficiency with which it works, are among the most gratifying things I have learned. Neither does its utility end with stopping the hæmorrhage at the moment; often have I watched a muscle-graft forming the centre of a rapidly-spreading mass of granulation tissue, which later helped considerably in the protection and closure of the wound.

If entrance to the cranium has to be made with a trephine, that tool should be applied immediately adjacent to, rather than directly over, the depressed fracture. Much time is saved by very light quick movements with the trephine held with both hands, the bone being kept wet by constant irrigation. The trephine hole or the original wound in the bone, if that be of a suitable size, is rapidly enlarged until a good half-inch of normal dura mater is exposed round the complete circumference of the wound therein.

The instrument I have been using for this purpose is Hoffmann's forceps, employing it boldly to grasp and tear away pieces of bone, rather than as a cutting or nibbling instrument. Large areas of skull can be quite quietly removed with slow steady pressure, and with no jarring to the brain, in a remarkably short time.

When this is completed—and it should be completed in ten minutes—the irrigation fluid is changed to hydrogen peroxide, and investigation of the lacerated brain is commenced. Obvious foreign bodies, etc., are lifted or

washed out—it is astonishing what foreign bodies will wash out of the brain. It is essential that the line of original rupture in the dura mater be not interfered with in any way; intradural arachnoid adhesions seem to form about as rapidly as do peritoneal adhesions, and on them depends the outcome of one of the great risks to the patient's life, namely, subdural or direct meningitis—that is, meningitis spreading from the wound in the dura mater, as opposed to meningitis via the ventricles, or ependymitis. Any blood-clot (and there is usually a surprising amount of this) is scraped or washed away. The irrigating fluid is again changed to 1–40 carbolic (temperature 110°), an unperforated rubber sheet or dam put over the exposed dura mater and brain, and a big perforated rubber sheet over the wound area. The original operation flaps are turned down over this, and the wound is dressed with 1–20 carbolic on cyanide gauze. Half a grain of morphine is then given, and the patient returned to bed. As much more morphine as may be necessary to keep the man quiet for forty-eight hours is given as occasion arises.

The only other drugs employed are (1) urotropine in 10-gr. doses, given every six hours from the first in every case; (2) aspirin and trional together, 10 gr. each, as frequently as may be necessary to control the headache which is often present in the earlier stages. These drugs are remarkably efficacious in their action. Antistreptococcic serum has lately been given to all cases on arrival; but cultures are always taken at once, and the bacteriological diagnosis settled in a few hours.

The first dressing is done about sixteen hours after the operation. The dressings are removed with hydrogen peroxide, and the forceps taken off; I have never had trouble of any sort in connection with this method of dealing with the scalp vessels, which saves both time and loss of blood. Afterwards the cases are dressed every twelve hours, still with cyanide gauze wrung out of 1–20 carbolic. Rubber dams are used throughout, and the scalp flap is not allowed to fall into position until it is certain that the sepsis in the deeper parts of the wounds is completely under control.

Lumbar Puncture has been used in this series of cases on but few occasions. The size of a cerebral hernia is no useful guide as to intracranial pressure, or to prognosis. Many of these cases developed enormous cerebral herniæ; but they subsided in the end with no treatment other than frequent careful dressings; general signs of intracranial pressure are very rare after the operative treatment described. A large number of the cases were systematically examined by Lieutenant Wheeler, the ophthalmic surgeon, for swelling of the optic disc. It was never found after a big decompression had been done, even though a very large hernia might be present; on the other hand, it was present when the decompression had been insufficient.

The effects of lumbar puncture are very transitory, lasting a few hours at the most. Its performance cannot fail to mean an added strain to a case that has already as much as it can bear. It is better to trust to free decompression for the relief of intracranial pressure. The cases in which lumbar puncture is likely to be of any use are comparatively few, and consist of those with meningitis, and not those with increased intracranial pressure due to other causes.

On the Selection of Cases for Operation.—This perhaps is the most important as well as the most debatable point in dealing with wounds of the cranium. One of three principles may be pursued, viz. :—

1. *The Radical Principle.*—To operate on every case when the skull is fractured or penetrated.

2. *The Conservative Principle.*—To operate on no case unless there be definite clinical evidence of increasing intracranial mischief.

3. *The Selective Principle.*—To operate on selected cases, chosen according to certain general rules.

A decision as to the respective merits of these principles is by no means simple, and could only be made by comparing the results of three operators working with a large number of cases under exactly similar conditions. It is at once clear that the period at which cases come for treatment, and the conditions under which the operation is to be performed, must greatly influence our decision. Thus, under good conditions, it is probable that the radical principle should be followed when cases arrive within three days of injury; during this period it is possible to prevent or mitigate the effects of sepsis, and therefore it would seem to be reasonable, in every case where the skull is certainly or probably fractured, to explore, trephine, and then act according to the conditions discovered. Similarly, when cases arrive at a late period, fourteen days or more after injury, the second or conservative principle is clearly indicated, although even in such circumstances certain cases should still be submitted to operation apart from clinical symptoms, if the *x* rays show that splinters of bone are driven into the cortex cerebri. It is in the intermediate period, with which this paper is concerned—i.e., when the cases arrive seven to ten days after injury—that one must have recourse to the selective principle, and base the decision for operation upon the clinical and bacteriological evidence in each case.

The following conditions without doubt demand immediate operation :—

(1) Active septic processes in a badly drained wound : (2) Evidence of cerebral irritation, as fits, restlessness, or delirium ; (3) Evidence of cerebral compression, notably severe headache ; (4) Coma and slow pulse.

Among these there is an important and large group of cases in which some consideration is necessary. The patient is comparatively well ; he is sleepy, but can be roused to speak quite sensibly, and he knows where he was wounded and how he was transported ; the one notable sign is that the pulse is slow—between 40 and 60. Such cases as these have generally been wounded in the silent areas of the brain, since those wounded in the Rolandic or occipital regions will present the more obvious signs of paralysis, blindness, or other alteration of vision. These patients are often very loath to submit to operation, and at one time I felt some hesitation in pressing it. But as experience has accumulated, I am quite clear that it is one's duty to urge operation upon all such, and I have never had reason to regret it. In these comparatively placid patients one is constantly surprised by the amount of damage done—a large area of internal table separated into fragments and driven into the brain, while the outer table only shows a trivial gutter fracture.

Cases in which operation is demanded by the conditions, but should if possible be deferred.

This group consists essentially of those with active and acute sepsis of the scalp associated with evidences of cerebral compression or irritation. In these cases, before opening the skull, it is necessary first to clean and drain the superficial tissues, a result which can usually be accomplished within twenty-four hours, by free incisions and boracic fomentations changed hourly, with the application of hydrogen peroxide on each occasion. *Case* 73 illustrates this type.

Cases requiring an operation, which may be postponed according to convenience.

Clean cases, in which the *x* rays demonstrate depressed fragments of bone; and those with foreign bodies of moderate size, which can be localized definitely and are in positions which can be reached without further injury to the brain.

Cases in which no operation is required.

These are as follows: (1) Those with no evidence of sepsis, bone displacement, or a foreign body; (2) Those with no evidence of sepsis, but with a foreign body not causing progressive symptoms; (3) Cases already submitted to a primary operation, in which both free drainage and efficient decompression have been provided.

Cases about which there must always be some doubt as to operating.

1. Those patients whose general and local conditions are apparently hopeless. Here it is unwise to come to any final determination at once. A delay of twenty-four hours, with appropriate treatment and observation, will often justify interference. General stimulation by warmth and by coffee enemata, combined with active disinfection of the wound, serve to encourage the latent vitality, whilst a skiagram may show whether there is any definite bony or foreign body which requires removal (see *Case* 19). By following this plan, it will often be found that not only will the local sepsis have cleared up largely, but also signs of grave nerve lesions will have become modified in a favourable direction. For example, a double plantar extensor reflex has either disappeared or become normal; absent knee-jerks have reappeared within twenty-four hours. No doubt this amelioration of symptoms is in the main accounted for by the benefit of rest upon patients who since their injury have been subjected to several transportations, a sea voyage, and a motor ride over rough roads.

2. Cases already operated upon, in which the wound is healed but the general condition remains unsatisfactory (see *Case* 100). There are no localizing symptoms of compression or irritation; but the patient is dull and apathetic, lying perfectly still without complaint, and exhibiting marked emaciation. Pulse and temperature are normal. The patient has to be fed, but will take nourishment well, even when fed by a stomach tube. After a period of weeks or days, the temperature may suddenly rise and the patient die in thirty-six hours, or on the other hand he may slowly recover. The explanation of this group of cases would appear to be that there has been a severe brain lesion, accompanied by hæmorrhage into the ventricles, but without primary infection. The general vitality is much lowered, and the

ultimate issue depends upon the occurrence or otherwise of a secondary infection, which in our cases has always been by the *Staphylococcus albus*.

3. Cases with healed wounds and no local evidence of sepsis, but with a foreign body in a position which can only be reached with difficulty, and with symptoms of grave cerebral injury but not of cerebral compression. In this group it would appear to be wise to give a waiting policy every possible chance, for if the symptoms are due to destruction of nerve tissue, an operation will do no good, whilst if they arise from general cerebral disturbance, this may be increased by an operation of some gravity and uncertainty (see *Case* 94).

Of the cases which I have observed, 104 have been submitted to operation, and 14 have been left without. Two of the latter were advised to have operations, but refused. All the operated cases and four of the non-operated (*Cases* 64, 92, 93, and 94) are detailed in the list given below. The remaining twelve were trivial gutter fractures in silent areas of the brain, and were sent to England shortly after admission.

On the Period elapsing after Injury before the Operation is performed.—The common idea, in which I shared when I began this work, is that the time which has elapsed between the infliction of the wound and the patient's arrival in hospital is a dominant factor in the prognosis. But this view is certainly not borne out by the facts here presented. The statistical table shows a mortality of over 50 per cent in the cases which had been operated on before arrival, and a mortality of under 10 per cent in those where primary operation was held over until their arrival at this hospital. This was certainly not due to the selection of the worst cases for early operation on board ship. In fact, the reverse was the case, and in almost all those which had been operated upon before arrival, the nature of the injury had been a small and simple gutter fracture, whilst the bad perforating wounds with severe cerebral symptoms had been left alone.

Further, it is quite evident that this high mortality of cases operated upon during transport is directly due to the incidence of streptococcic infection. Thus, in the cases already operated upon before arrival, streptococcic infection was present in 58 per cent, whilst in those on whom no previous operation had been undertaken the percentage is 3.

Another point which has revealed itself with an insistency which cannot be ignored is that so many cases operated on during transport have had their scalp incisions sewn up, and that these cases for the most part have ended fatally. When such wounds have had to be re-opened, it has been frequently found that foreign bodies, bits of bone, and pus have been left embedded in the patient's brain.

At a time when the uselessness of antiseptics and the value of suturing scalp wounds are being proclaimed so loudly, it may be well to draw attention to the danger of streptococcic infection of operation wounds, and to the grave risks which are incurred by suturing the scalp.

LIST OF CASES, WITH ABSTRACT OF CLINICAL AND POST-MORTEM NOTES.

NOTE.—In all the following cases, unless it is otherwise stated, the operation as described in the text was performed.

P.b.a. = *Period before admission.* U.o. = *Period under observation.*

Case 1.—P.b.a. unknown; U.o. 6 weeks. Right occipital, intradural; blindness and diplopia; removal of shrapnel ball from brain.
Recovery complete, including sight.

Case 2.—P.b.a. 10 days; U.o. 3 weeks. Mid-frontal region; rifle bullet impacted in skull, wound healed, intense headache; superior longitudinal sinus torn, closed with gauze. *Complete recovery.*

Case 3.—P.b.a. unknown; U.o. 8 weeks. Through-and-through frontal region, exit on the left; infection, *Staphylococcus aureus*; unconscious on arrival; immediate operation; hernia developed at site of both wounds, worse on left; long anxious convalescence, imbecile and very mischievous for a week; incontinence of urine.
Recovery complete, except that partial incontinence remained.

Case 4.—P.b.a. 5 days; U.o. 8 weeks. Through-and-through right frontal region, exit through globe of right eye; bone and pus removed from brain, eye excised, but orbit not laid open into main wound; long-continued suppuration in orbit. This case decided me to freely open orbit into main incision in the future.
Complete recovery except for the loss of the eye.

Case 5.—P.b.a. unknown; U.o. 2 weeks. Left Rolandic area; simple gutter fracture, dura not torn, extradural clot; paralysis of right arm. *Complete recovery.*

Case 6.—P.b.a. unknown; U.o. 3 weeks. Mid-occipital; large extradural hæmorrhage from superior longitudinal sinus, otherwise dura uninjured; no functional symptoms. *Complete recovery.*

Case 7.—P.b.a. unknown; U.o. 4 weeks. Right occipito-parietal; long gutter fracture, rifle bullet lying between scalp and skull; dura torn; bone and pus removed from brain; slow pulse; stormy convalescence. *Complete recovery.*

Case 8.—P.b.a. unknown; U.o. 4 weeks. Large left temporo-parietal gutter fracture; bone and pus removed from brain; large decompression; extremely cheerful, almost exalted, during first week. *Quick and complete recovery.*

Case 9.—P.b.a. unknown; U.o. 5 weeks. Large gutter fracture in left Rolandic area; a half shrapnel ball impacted in inner table; dura extensively torn; big decompression; right hemiplegia. Pieces of bone extruded from hernia on three successive days, ten days after operation.
Smooth recovery, complete except for hemiplegia, which had almost disappeared.

Case 10.—P.b.a. unknown; U.o. 2 weeks. Left parietal gutter fracture; shrapnel fragments removed; dura not opened; decompression.
Complete recovery.

Case 11.—P.b.a. unknown; U.o. 6 weeks. Large right frontal gutter fracture, caused by shell; dura torn; large pre-operative hernia, which was removed.
Complete recovery.

Case 12.—P.b.a. 6 days; U.o. 4 weeks. Large left parieto-occipital gutter fracture; severe general fits for three days; right hemiplegia, worst in leg, slight astereognosis. *Recovery good, but incomplete as regards right leg.*

Case 13.—P.b.a. unknown ; U.o. 4 weeks. Large right parietal gutter fracture, due to shrapnel ; bone and pus removed from brain. *Complete recovery.*

Case 14.—P.b.a. unknown ; U.o. 2 weeks. Small left occipital gutter fracture ; extensive extradural clot ; dura not torn ; blindness and hemiplegia. *Complete recovery.*

Case 15.—P.b.a. unknown ; U.o. 2 weeks. Right frontal gutter fracture, opening frontal sinus ; dura not torn ; large extra dural clot and pus ; scalp very œdematous and crackling. *Complete recovery.*

Case 16.—P.b.a. 13 days ; U.o. 4 days. Operation before admission ; *Streptococcus* ; fits starting in left hand and becoming general ; a small trephine hole had been made in the right parietal region, and the wound had been sewn up ; large decompression done ; bone and pus removed from brain. *Died four days later with fits. No autopsy.*

Case 17.—P.b.a. 5 days ; U.o. 4 weeks. Left parietal wound, operation before admission, small trephine wound sewn up ; *Staphylococcus aureus* ; large decompression done ; bone and pus removed from brain. *Complete recovery.*

Case 18.—P.b.a. unknown ; U.o. 5 weeks. Left fronto-parietal injury ; operation before admission ; *Staphylococcus aureus* ; large decompression ; removal of bone, pus, and shrapnel ball from brain ; appeared to be a hopeless injury. Desperately ill for many days, then slowly recovered and got into sitting-up stage ; sudden rise of temperature to 103°, with increase of hernia ; fits ; second large decompression done after consultation with Sir Victor Horsley. *Death next day.*

Autopsy.—Internal pyocephalus, purulent meningitis, cerebritis ; bullet and operation wound in left fronto-parietal region, with mass of sloughing brain substance protruding from cranial cavity 3 in. in diameter. Adhesion between pia and dura at edges of hernia cerebri. Cerebritis extending down to and involving the anterior horn of the left lateral ventricle. Softening involving the whole of the left frontal lobe and spreading into the internal capsule. Pus in all the ventricles of the brain, with moderate distention. Basal meningitis with much matting of meninges and turbid subarachnoid œdema.

Case 19.—P.b.a. unknown ; U.o. 10 weeks. Operation before admission ; left occipito-parietal injury ; *Staphylococcus aureus* ; large deep gutter fracture probably due to shrapnel ; arrived apparently dying. Operation postponed for 10 hours in hope of improving condition. Large decompression ; removal of bone and pus ; comatose for days. Very slow recovery, extrusion of pieces of bone from hernia three weeks after operation. Hernia disappeared. *Complete recovery, confirmed by subsequent letter.*

Case 20.—P.b.a. 8 days ; U.o. 6 weeks. Left occipital injury ; *Staphylococcus albus* ; gutter fracture with laceration of dura ; bone and pus removed from brain ; eye troubles for a time. *Complete recovery.*

Case 21.—P.b.a. 8 days ; U.o. 4 weeks. Through-and-through from left parietal to left frontal ; *Staphylococcus albus* ; left eye removed and orbit opened into anterior wound ; bone and pus removed from brain. *Complete recovery, confirmed by letter five months later.*

Case 22.—P.b.a. unknown ; U.o. 1 day. Through-and-through parietal region ; operation before admission ; *Streptococcus* ; apparently hopeless ; wound was stinking ; opened up wound with further decompression, superior longitudinal sinus torn, closed by muscle graft. *Died within twenty-four hours. No autopsy*

Case 23.—P.b.a. 8 days; U.o. 10 weeks. Operation before admission; left occipito-parietal shrapnel wound; infection by *Staphylococcus aureus* and *albus* and by *Streptococcus*; complicated by another wound in neck; big decompression; removal of ball, bone, and pus from brain; ball removed from neck; both head and neck wounds suppurated freely; acidosis (delayed chloroform poisoning) for forty-eight hours. Slow convalescence.

Complete recovery, confirmed by subsequent letter.

Case 24.—P.b.a. 7 days; U.o. 17 weeks. Right fronto-parietal wound; *Staphylococcus albus*; usual decompression; tedious convalescence complicated by erysipelas. *Complete recovery.*

Case 25.—P.b.a. 5 days; U.o. 2 weeks. Right frontal; rifle bullet removed from skull; dura torn. *Complete recovery.*

Case 26.—P.b.a. 10 days; U.o. 14 weeks. Right frontal, through-and-through, exit at right eye. This case and No. 28 staggered into the same ward within five minutes of one another, being sent up as 'sitting cases;' they had almost identical injuries. Large decompression, and removal of right orbit; after a few weeks developed pyrexia, temperature 103°; then this subsided, but subsequently he developed paratyphoid. *Final complete recovery, confirmed by letter six months later.*

Case 27.—P.b.a. 5 days; U.o. 3 weeks. Right parietal gutter fracture; simple decompression, subdural hæmorrhage, dura not opened.

Complete recovery, confirmed by letter five months later.

Case 28.—P.b.a. 10 days; U.o. 10 weeks. Right temporal and right orbit; walked into ward! Free decompression, orbit opened up and eye removed; *Staphylococcus albus*; after apparent recovery, developed septicæmia with the above organism in blood; injections of neosalvarsan given without result.

Died after three weeks' pyrexia.

Autopsy.—Operation wounds firmly healed and cicatrized; a most careful dissection failed to reveal any collection of pus or even of recent granulation tissue which might have been the origin of the septicæmia. The meninges, brain substance, and ventricles appeared normal. The process of repair and protection in the area of exposed brain was interesting; very dense tough fibrous tissue joined the edges of the wound of the dura; the substance of the brain was adherent to this, but there seemed to be no secondary changes taking place in it.

Case 29.—P.b.a. unknown; U.o. 2 weeks. Extensive right parietal injury; *Staphylococcus aureus*; large decompression; hopeless from the outset, unconscious most of the time. It was remarkable in view of the post-mortem findings that he lived so long. *Death after fourteen days.*

Autopsy.—Purulent encephalitis, internal pyocephalus, and basal meningitis. Operation wound in right parietal bone, 1 in. from fronto-parietal suture and 1 in. from mid-line; bullet track running backwards and downwards through right cerebrum across corpus callosum to finish in proximal part of left occipital lobe; purulent cerebritis with diffluent softening of nearly the whole of the right parietal lobe and part of the left occipital lobe. Inflammation spreading through wall of the right lateral ventricle. Pus in all the ventricles of the brain. Thin purulent fluid in basal cisterna, with leptomeningitis spreading along the main fissures. Fragment of brass casing in left occipital lobe.

Case 30.—P.b.a. unknown; U.o. 3 weeks. Right occipital gutter fracture, with laceration of dura; *Staphylococcus aureus*; usual decompression operation; removal of bone from brain; blindness lasting for six days. *Complete recovery.*

Case 31.—P.b.a. 4 days; U.o. 10 weeks. Operation before admission; left frontal injury; *Streptococcus*; operation wound had been sewn up; re-opened; big decompression; removal of bone, blood-clot, and pus from brain; anxious and stormy convalescence, bone being extruded from hernia ten and thirteen days after operation; dysentery. *Complete recovery.*

Case 32.—P.b.a. 4 days; U.o. 6 weeks. Left frontal injury; operation before admission; *Staphylococcus aureus*; arrived comatose, operation wound had not been sewn up; blood-clot and pus removed from brain. *Rapid and complete recovery.*

Case 33.—P.b.a. 6 days; U.o. 8 weeks. Right parietal injury; operation before admission, small trephine, not sewn up; *Staphylococcus aureus*; decompression and removal of shell fragment, bone, blood-clot, and pus from brain. Uneventful convalescence; up and working in ward.

Sudden death on getting out of bed at night.

Autopsy.—Head wound granulating. Thrombosis of coronary arteries; atheromatous button at origin of the anterior descending coronary artery; recent granular adherent thrombus blocking orifice of this vessel; a few fat flecks in the rest of both coronary arteries and in aortic commissure. . . . Several scarred ulcers in large intestine . . . Clean wound of scalp and skull in left fronto-parietal region; surface of dura granulating. Slight subarachnoid œdema; very slight dilatation of all the ventricles of the brain, with excess of clear fluid; no meningitis or flattening of convolutions.

Case 34.—P.b.a. unknown; U.o. 10 weeks. Double frontal injury; *Staphylococcus aureus*; apparently hopeless; almost all external parts of both frontals smashed, and a great part removed at operation; superior longitudinal sinus torn across; muscle grafted; tedious but smooth convalescence.

Complete recovery, with good mental condition.

Case 35.—P.b.a. unknown; U.o. 6 weeks. Left frontal gutter fracture, with laceration of dura; *Staphylococcus aureus*; injury of left eye, with prolapse of iris; bone and pus removed from brain; iridectomy. *Complete recovery.*

Case 36.—P.b.a. 7 days; U.o. 9 weeks. Right temporo-frontal injury; *Staphylococcus aureus*; half a shrapnel ball, bone, and pus removed through large opening; right orbit cleared out; smooth convalescence.

Complete recovery, confirmed by letter four months later.

Case 37.—P.b.a. unknown; U.o. 6 weeks. Left Rolandic region; *Staphylococcus aureus*; large decompressive operation; dura torn; pieces of bone removed from brain, large intra- and extradural clots; smooth convalescence.

Complete recovery.

Case 38.—P.b.a. unknown; U.o. 6 weeks. Right frontal injury; violently maniacal, with generalized fits; much splintering of internal table; bone fragments and blood-clot removed from the brain; skull was of exceptional thickness; no fits after the second day; working well in the ward before departure.

Complete recovery.

Case 39.—P.b.a. unknown; U.o. 10 weeks. Double frontal injury; *Staphylococcus aureus*; complicated by injury to eyes and mouth; large decompression, most of left frontal bone being removed, also left eye; longitudinal sinus torn; muscle grafted. *Complete recovery except for loss of left eye.*

Case 40.—P.b.a. unknown; U.o. 13 weeks. Right frontal injury; *Staphylococcus aureus*; both upper and lower jaws fractured; large decompression; bone and pus removed from brain. *This case appeared hopeless, but made complete recovery in respect to his mental condition.*

Case 41.—P.b.a. unknown; U.o. 9 weeks. Through-and-through the left temporal region; also large shell wound of back, and a fracture of the base of the skull; comatose; operation delayed for a day and then done without anæsthetic; bone and pus removed from brain, finger passed into large basal hæmorrhage; drained with silkworm gut; very anxious convalescence for ten days. *Complete recovery.*

Case 42.—P.b.a. unknown; U.o. 3 weeks. Simple gutter fracture of right frontal region, extradural; decompression. *Good recovery, but developed dysentery.*

Case 43.—P.b.a. unknown; U.o. 3 weeks. Simple gutter fracture of right frontal region, extradural; simple decompression, with removal of extradural clot, dura not opened. *Complete recovery.*

Case 44.—P.b.a. unknown; U.o. 4 weeks. Left occipital gutter fracture; simple decompression; dura lacerated in several places; removal of extradural clot and of some splinters of bone from brain. *Complete recovery.*

Case 45.—P.b.a. unknown; U.o. 4 weeks. Right parietal injury; simple decompression, dura not torn, removal of extradural clot. *Complete recovery.*

Case 46.—P.b.a. unknown; U.o. 3 weeks. Right frontal injury; comatose; simple decompression, removal of extradural clot. *Complete recovery.*

Case 47.—P.b.a. unknown; U.o. 1 day. Operation before admission; *Streptococcus*; through-and-through superior occipital region; arrived shouting and maniacal. Operation, removal of most of the occipital bone; superior longitudinal and both lateral sinuses thrombosed. *Died after twenty-four hours.*

Case 48.—P.b.a. 7 days; U.o. 6 weeks. Right frontal injury, destruction of both eyes, loss of right arm, and shell wounds of both thighs and of chest wall. Bone removed from brain. *Apparently dying for three days, but then rapid recovery, which has been confirmed by a subsequent letter.*

Case 49.—P.b.a. 7 days; U.o. 4 days. Double frontal injury; operation before admission; *Streptococcus*; wound had been sewn up; violent suppuration; large decompression, removal of bone, pus, and shrapnel ball from brain. *Died after four days.*

Case 50.—P.b.a. 7 days; U.o. 3 days. Right midparietal injury; operation before admission, sewn up; *Streptococcus*; free decompression, removal of bone, pus, and shrapnel ball from brain. *Death in three days.*

Autopsy.—Encephalitis; purulent, direct radial leptomeningitis. Sloughing brain protruding from midparietal region. Large collection of blood-stained pus beneath dura on right side. Softening with encephalitis of whole of parietal and occipital lobes. Slight internal pyocephalus. No thrombi in sinuses.

Case 51.—P.b.a. unknown; U.o. 9 weeks. Through-and-through occipital region; *Staphylococcus aureus*; blindness complete; decompressive operation at each wound; bone and pus removed from brain; bits of bone extruded from brain seven, nine, and fourteen days after operation; vision slowly recovered after ten days, colours first and red first of all; could read easily when sent to England. *Complete recovery, confirmed by subsequent letters.*

Case 52.—P.b.a. 7 days; U.o. 6 weeks. Left occipital injury; *Staphylococcus aureus*; stone blind; large decompression done, with removal of blood-clot, bone, and pus from brain; vision slowly recovered after fourteen days, colours first—red, then blue. *Complete recovery.*

Case 53.—P.b.a. 56 days ; U.o. 5 weeks. Left Rolandic area ; had had a bullet wound in scalp which had healed. Eight weeks later was admitted to medical ward for dysentery ; whilst in this ward he had three Jacksonian fits ; healed scar in left Rolandic area ; almost complete hemiplegia, and paralysis of left external rectus ; had intense headache and diplopia. Area of thickened bone two inches in diameter removed ; dura densely thickened and adherent.

Rapid recovery of movement, becoming complete in five weeks, except for paralysis of the left external rectus, which persisted.

Case 54. — P.b.a. unknown ; U.o. 5 weeks. Right temporosphenoidal gutter fracture ; decompression without opening dura ; contracted dysentery.

Complete recovery.

Case 55.—P.b.a. 7 days ; U.o. 5 weeks. Right temporosphenoidal shell wound with gutter fracture ; *Staphylococcus aureus* ; bone and pus removed from brain.

Rapid and complete recovery.

Case 56.—P.b.a. 9 days ; U.o. 9 days. Operation before admission ; *Streptococcus* ; right parietal and vertex regions ; scalp wound had been sewn up ; sepsis very acute ; large decompression ; superior longitudinal sinus thrombosed, but bled sharply during operation and afterwards. *Death.*

Autopsy.—Cerebritis ; internal pyocephalus ; direct leptomeningitis ; amœbic dysentery ; gutter fracture in the right parietal bone, with marked encephalitis spreading to the lateral ventricle. Pus in the ventricle, with purulent basal meningitis. Slight dysenteric ulceration in colon and rectum.

Case 57.—P.b.a. 9 days ; U.o. 8 weeks. Left Rolandic injury ; *Staphylococcus aureus* ; right hemiplegia, worst in the arm ; bone and pus removed through a very large decompression ; large hernia formed. Several fits during first week ; long and stormy convalescence. *Power slowly returning on discharge. Subsequent letter stated that recovery was progressing.*

Case 58.—P.b.a. 6 days ; U.o. 4 days. Operation before admission ; *Streptococcus* ; through-and-through wound of vertex, which had been sewn up ; pus, blood-clot, and bone débris removed from brain. *Died of septicæmia.*

Case 59.—P.b.a. unknown ; U.o. 7 days. Operation before admission ; *Streptococcus* ; right occipitoparietal injury ; large decompression ; removal of bone and pus from brain ; had unusual eye signs, the eyes swivelling round independently ; *x* rays showed half a shrapnel ball lying on the crus cerebri. Improved for five days, then became worse ; whilst the question of an operation for the removal of the ball (practised on a cadaver) was being considered, the patient died. *Death.*

Autopsy.—Cerebritis, internal pyocephalus, and basal meningitis ; operation wound in right parietal bone ; track through right cerebral hemisphere via lateral ventricle and crus to fourth ventricle ; half a shrapnel ball lay in the fourth ventricle ; extensive softening of parietal and temporosphenoidal lobes ; thin purulent fluid in all the ventricles and in basal cisterns.

Case 60.—P.b.a. unknown ; U.o. 2 weeks. Left Rolandic area ; fits before and three fits after operation ; extradural hæmorrhage, dura not torn ; simple decompression. *Complete recovery.*

Case 61.—P.b.a. 10 days ; U.o. 7 days. Double frontal injury ; operation before admission ; *Streptococcus* ; very severe injury ; large decompression ; right eye removed ; large stinking hernia removed ; nose opened into wound. Continuous hiccough for last four days.

Did well for four days, and then went down-hill and died.

Case 62.—P.b.a. 7 days; U.o. 4 weeks. Cerebellar injury; *Staphylococcus aureus*; gutter fracture near foramen magnum, hole in dura the size of a shilling; shrapnel ball found imbedded in the axis vertebra, which was fractured; removed; wound left completely open. *Smooth and complete recovery.*

Case 63.—P.b.a. unknown; U.o. 1 day. Right posterior parietal and occipital injury; operation before admission; *Streptococcus*; very severe injury; bone and pus in the brain, removed through a large decompression operation; intense restlessness; large doses of morphia; cessation of respiration; artificial respiration for two hours. *Death next day.*

AUTOPSY.—Purulent basal meningitis, internal pyocephalus, purulent cerebritis. Operation wound in posterior part of right parietal and occipital bones, sloughing of subjacent brain substance; ependymitis in posterior horn of right lateral ventricle, pus in all the ventricles. Purulent meningitis starting from base and spreading almost to vertex.

Case 64.—P.b.a. unknown; U.o. 13 weeks. Right temporo-occipital injury; operation before admission; *Staphylococcus aureus*; general and local condition very similar to next case (No. 65). Large stinking hernia bulging from operation wound. Appeared to be hopeless, and no operation was done. He remained alive, and for many days that is all that could be said. Coma alternated with a feeble, tremulous restlessness, and meanwhile the hernia grew larger and larger, and finally attained the size of two fists. After six weeks he could walk about, with the large actively pulsating cerebral hernia. In view of the subsidence of the hernia in *Case* 65 after decompression, I greatly regretted having left this man alone. Pure formalin was painted on the hernia, and slices were cut away daily. He became distinctly worse under this treatment. *X* rays revealed the presence of half a shrapnel ball lying on the tentorium on the right side.
Transferred to England as a walking case.

Case 65.—P.b.a. unknown; U.o. 10 weeks. Left occipital injury; operation before admission; *Staphylococcus aureus*; wound had been sewn up, stitches were bursting open, and stinking brain and pus were oozing through; operated upon in desperation, large decompression done and big stinking cerebral hernia removed. Was stone blind; for days seemed hopeless; hernia, size of an orange, re-formed. After a long and stormy convalescence, the hernia subsided completely and the vision was restored. Compare this with *Case* 64, in which no decompressive operation was done. *Ultimate complete recovery.*

Case 66.—P.b.a. 9 days; U.o. 6 weeks. Left occipital injury; *Staphylococcus albus*; intense headache, blindness; decompression operation, bone removed from brain; base of skull was fractured; large basal hæmatoma (cf. *Case* 41).
Smooth and quick recovery.

Case 67.—P.b.a. unknown; U.o. 9 weeks. Left occipitoparietal injury; operation before admission; *Streptococcus*; wound had been sewn up, big stinking hernia bursting through stitches; blind; large decompressive operation, removal of hernia; sight returned, first for red, then for other colours. *Complete recovery.*

Case 68.—P.b.a. 6 days; U.o. 5 weeks. Midfrontal injury; *Staphylococcus albus*; jaundice; deep gutter fracture with laceration of dura; extensive decompression, superior longitudinal sinus torn, muscle graft. *Complete recovery.*

Case 69.—P.b.a. unknown; U.o. 4 weeks. Right Rolandic area; left hemiplegia; shrapnel ball in skull; large subdural hæmorrhage, but dura not perforated; paralysis recovered from within 48 hours. *Complete recovery.*

Case 70.—P.b.a. 6 days; U.o. 4 weeks. Left occipital injury; *Staphylococcus aureus*; large extradural clot removed through a three-inch decompression; dura not torn. *Complete recovery.*

Case 71.—P.b.a. unknown; U.o. 10 weeks. Left Rolandic injury; *Staphylococcus aureus*; complete right hemiplegia, including face, complete aphasia. Very ill; free decompression, bone and pus removed from brain; for ten days his case was despaired of, then slowly improved; a very large cerebral hernia formed, and after a long time commenced to retire; patient by this time miserably wasted, still aphasic, and generally softly weeping. After five weeks he began to improve rapidly. Movements of right leg appeared first, then of right arm, and finally he commenced to say, "We, we, we." This stage lasted for five days. Suddenly one day he said, "Good morning, doctor," and from that moment his speech returned rapidly. *A month after discharge he wrote, "I am very well, and am writing this with my bad hand."*

Case 72.—P.b.a. 5 days; U.o. 9 weeks. Injury on the vertex; operation before admission; *Staphylococcus aureus*; wound re-opened, bone and pus removed from brain, with large decompression. *Complete recovery.*

Case 73.—P.b.a. 7 days; U.o. 6 weeks. Left occipitoparietal injury; operation before admission; *Staphylococcus aureus*; ticket stated, "Incision revealed stellate fracture of skull which was not opened as it did not seem depressed." The wound had been sewn up, and the whole scalp was stinking, œdematous, and suppurating. Very violent fits on arrival. Operation the same night. Wound had been sewn up with seven fishing-gut sutures, between which stinking pus issued. The sutures were removed, the wound was washed with hydrogen peroxide, and fomentations were applied, in the hope that any interference which should be necessary might be postponed until the condition of the scalp became less unfavourable. During the evening, a succession of four fits, culminating in the most violent one I have ever seen, made it apparent that if any attempt to save the patient's life were to be made, it had to be made immediately. A large area of scalp (between 1½ and 2 inches thick with œdema) was excised around the original wound. A stellate fracture was found, blackened in the centre by the bullet. An inch trephine was applied just to the side of this, and an area of bone 2 inches in all diameters removed—including the fractured area. An extradural hæmorrhage the size of a golf ball was found beneath this, and washed away. It was then seen that a long thin spicule of internal table had been driven vertically into the brain, piercing a small branch of the middle meningeal artery, which had bled both inside and outside the dura.

The intradural hæmorrhage had spread internally over the Rolandic area, and was presumably the cause of his fits. It was obvious that two courses were open: (1) To enlarge the opening in the dura and deal with the intradural clot directly; (2) To do a large decompression, and so spare the man the enormous risk of infection from his stinking septic scalp. The latter was decided on, and an area of bone some 4 inches by 3 inches removed. He had another severe fit immediately after his operation, and from that time has made a swift and uninterrupted recovery.

I have learnt from this case that the dura mater is not the rigid and unyielding membrane that it is stated to be, inasmuch as within twenty-four hours this man's dura mater with subjacent intradural blood-clot was bulging a quarter of an inch outside *the outer limit of his bone opening*. From the condition of this case one month after operation I am satisfied that if the bone decompression be sufficiently free it is unnecessary to open the dura to deal with a subdural hæmorrhage, which in such a septic case as this would very gravely endanger the patient's life. The man is up, and working in the wards in full health.

Complete recovery, somewhat retarded by an attack of influenza. Recovery confirmed by a subsequent letter.

Case 74.—P.b.a. 8 days; U.o. 4 weeks. Left Rolandic area; operation before admission; *Staphylococcus aureus*; right hemiplegia, wound not sewn up; bone and pus removed from brain. One fragment of bone was 1½ inches from the surface. *Rapid recovery, hemiplegia disappearing.*

Case 75.—P.b.a. 19 days; U.o. 13 weeks. Double frontal injury; fractured base; *Staphylococcus aureus* and *albus*; apparently hopeless; anterior half of scalp

turned down, both frontal bones smashed, also both zygomatic processes; left eye destroyed, orbit cleared out.

Rapid and complete recovery except for the loss of the eye.

Case 76.—P.b.a. unknown; U.o. 13 weeks. Through-and-through from left occipital to left Rolandic; *Staphylococcus aureus*; complicated by left pleurisy.

This case arrived extremely ill—quite unable to give any account of himself, and no ticket or notes which contained information of any value. Temperature 101°, pulse 100. Lay quietly in bed without moving, and when spoken to, smiled, and invariably replied, "Yes, Sarah," or "No, Sarah." No evidence of loss of power in any limb. Patient freely moved all his limbs, but when asked to do so, immediately replied, "No, Sarah," and remained quite passive. Nothing special about any reflexes. Usual operation done. Entrance wound of rifle bullet was found close to left side of external occipital protuberance, and dealt with through curved incision. Exit wound then explored, and necessitated such a large decompression that the two scalp wounds had to be thrown into one. Bone and pus removed from both. Infected areas of scalp excised freely, and wound partially closed by two sutures. A large hernia developed through exit wound, but this quickly retired within the skull. Thorough examination by Sir Victor Horsley and myself, later on, revealed that my original impression as to paralysis was correct.

It would appear that situated behind the speech centre is an area known as the psycho-coördination area, which presides over the grouping or coördination of muscles which take part in the performance of any voluntary movement. In other words, patient is able to use each muscle separately and to coördinate involuntarily, but quite unable to perform some specific complex action when asked to do so.

When asked to squeeze a hand, for instance (speech was perfectly understood), he waved his arms and moved his fingers, and after a few moments ceased, saying, "No, Sarah," or in a day or two, "I don't want to, Sarah," or "To-morrow, Sarah." For ten days "Sarah" entered into every single sentence. At the end of a week he could ask for things and was rapidly improving. Later still, when quite convalescent, a certain amount of chaff was indulged in by his companions, who had by this time, of course, nicknamed him "Sarah." This at first led to a most extraordinary vivid blush which spread almost all over his body. I am quite unable to advance any adequate explanation of this phenomenon, unless it indicated a vasomotor excitability. *Complete recovery.*

Case 77.—P.b.a. 7 days; U.o. 6 weeks. Left occipital region; had had fits. Decompression, removal of bone, pus, and a half shrapnel ball from brain; hemianopia, diplopia, vomiting. *Very stormy convalescence; then sudden death.*

Autopsy.—Purulent basal meningitis, internal pyocephalus, operation wound in left parieto-occipital region, edges of wound healthy. Small occipital hernia. Firm adhesions between skull, dura, and arachnoid round edges of hernia. Marked dilatation of all the ventricles of brain, valvular opening of posterior part of left lateral ventricle at apex of hernia; localized cerebritis of occipital lobe; pus in all ventricles with ependymitis, spread of inflammation from ventricles to basal cisterns. Purulent basal meningitis with yellow subarachnoid infiltration, spreading to vertex, chiefly on right cerebral hemisphere. Had lived for two weeks with fluid draining from ventricles.

Case 78.—P.b.a. unknown; U.o. 1 day. Through-and-through left fronto-temporal region; operation before admission; *Streptococcus*; removal of both eyes; decompression. *Death in twenty-four hours.*

Case 79.—P.b.a. 4 days; U.o. 3 weeks. Gutter fracture of vertex; *Staphylococcus albus*; decompression, removal of spicule of bone driven through longitudinal sinus, muscle graft; normal convalescence except for one fit a few hours after operation. *Complete recovery.*

Case 80.—P.b.a. 5 days; U.o. 6 weeks. Gutter fracture of vertex; operation before admission, incision, down to bone, not sewn up; *Staphylococcus aureus*; decompression, longitudinal sinus torn, muscle graft. *Complete recovery.*

Case 81.—P.b.a. unknown; U.o. 14 hours. Through-and-through left temporo-frontal region; *Staphylococcus aureus*; big decompression done; very severe injury, but apparently not hopeless; scalp very septic.
Died suddenly after fourteen hours.

AUTOPSY.—Internal pyocephalus; encephalitis; wound of entry in front of left ear, exit in left frontal region. Parts of left frontal and parietal bones had been removed. Septic track leading directly into the left lateral ventricle. Fragments of bone and one or two pieces of metal in the bullet track and in the left lateral and third ventricles. Slight internal pyocephalus. Some bruising of the tip of the left temporo-sphenoidal and of the right parietal and occipital lobes. Excess of fluid at the base.

Case 82.—P.b.a. unknown; U.o. 12 days. Double occipital injury; *Staphylococcus aureus*; whole back of skull smashed, cerebellum and both occipital lobes exposed. Longitudinal and both lateral sinuses torn and thrombosed. *Death.*

AUTOPSY.—Cerebritis, meningitis. Operation wound in right parieto-occipital region, sloughing brain substance protruding through a laceration of the dura; internal pyocephalus with moderate dilatation of the ventricles. Purulent basal meninigitis. Sloughing of whole of right occipital lobe, with softening extending to ventricle and affecting the basal nuclei. Half a shrapnel ball in the sloughing brain substance.

Case 83.—P.b.a. 8 days; U.o. 3 weeks. Left parietal area; *Staphylococcus albus*; operation before admission; nothing further done. *Complete recovery.*

Case 84.—P.b.a. unknown; U.o. 3 weeks. Right Rolandic area; had repeated fits; simple extradural decompression. *Complete recovery.*

Case 85.—P.b.a. 7 days; U.o. 7 weeks. Left temporal region. Large shell fragment removed from the brain; stormy convalescence. *Complete recovery.*

Case 86.—P.b.a. 9 days; U.o. 7 weeks. Through-and-through occipital region; *Staphylococcus albus*; complete blindness; large decompression; removal of large hernia, with bone and pus from brain.
Recovery slow but complete, including vision.

Case 87.—P.b.a. 7 days; U.o. 8 weeks. Through-and-through occipital region from above downwards. Usual operation; rifle bullet removed from lumbar region of spine, where it had lodged without doing damage. *Complete recovery.*

Case 88.—P.b.a. 5 days; U.o. 4 weeks. Left Rolandic area; fits; simple decompression, removal of extradural clot without injury to dura.
Complete recovery.

Case 89.—P.b.a. 4 days; U.o. 4 days. Through-and-through frontal region; *Staphylococcus aureus.* Wound apparently caused by rifle bullet, and about one and a half inches behind supra-orbital ridge. Wound of entry on right side. Wound of exit symmetrically placed on left side. Complained of intense headache, and suffered from incontinence of urine. (Compare *Case* 3.) Intense œdema of scalp and both orbits. Subconjunctival hæmorrhage in both eyes—in which, however, patient had appreciation of light. Pus and brain oozed from both wounds. The case was dealt with in the usual way. Both frontal bones were found smashed, and large portions of both were removed. Extensive subcranial hæmorrhage, which

was scraped and washed away. This was an apparently hopeless case from the start, and the fact that decided me to operate was the condition of both eyes.

Died after four days.

AUTOPSY.—Marked œdema of scalp and orbits ; subconjunctival hæmorrhage in both eyes. Large operation flap in left frontal region. Removal of a large part of left frontal bone and small part of right frontal, large gap in dura with protruding brain substance. Superior longitudinal sinus intact. Fissured fracture of orbital plate of left frontal bone and to a slight extent of cribriform plate of ethmoid and orbital plate of right frontal bone. Large amount of subdural hæmorrhage in all fossæ on left side and at base of brain. Cerebritis of whole of left frontal lobe spreading to, but not involving, the anterior horn of left lateral ventricle. Patch of cerebritis on the adjacent mesial surface of right frontal lobe. Marked *contrecoup* ecchymosis on right temporo-sphenoidal lobe. Some subarachnoid hæmorrhage on right parietal and occipital lobes.

Case 90.—P.b.a. unknown ; U.o. 1 day. Through-and-through right parietal region ; *Staphylococcus aureus*, *Streptococcus*, and *B. aerogenes capsulatus*. Arrived comatose with pulse 110, temperature 101°, and a note stating he had been " somnolent while on boat, but with no indications for interference." Through-and-through rifle bullet wound, complete left hemiplegia. He had long black hair, none of which had been removed, either with the scissors or razor, even round the edges of his wounds. Entire scalp and neck very œdematous and crackled ; smell was exceedingly penetrating. There was a fomentation five inches square covering the two small wounds of entry and exit. A large decompression was done at once and a cerebral abscess the size of a golf-ball opened and drained. It contained stinking dark brown pus and gas. He was given an intravenous infusion on the table, which he reached too late. *Death.*

AUTOPSY.—Internal pyocephalus, cerebritis, abscess in right parietal lobe. Marked inflammatory œdema of areolar layer of scalp ; œdema spreading down neck. Free operation, excision of scalp, removal of posterior part of right parietal bone. Sloughing brain substance protruding through extensive laceration of dura. Very slight fibrinous adhesion between dura and arachnoid around the laceration. Sloughing of nearly the whole of posterior half of right parietal lobe, limited deeply by a pyogenic membrane. Two fragments of bone in abscess cavity (size of golf ball). Cerebritis spreading to and through the external and inferior walls of posterior horn of right lateral ventricle, almost reaching the basal nuclei. Some dilatation of, but no fluid in, ventricles (ruptured via the wound). Marked subarachnoid ecchymosis (*contrecoup*) on left parietal lobe of brain. Some extradural clot at margins of operation incision. Fissured fracture of right temporal bone. (Autopsy done three and a half hours after death.)

Case 91.—P.b.a. 9 days ; U.o. 4 days. Gutter fracture of right parietal region ; *Staphylococcus aureus*. Intense headache, temperature 102°, one of the largest scalp flap incisions I have ever seen (not sewn up). and a case sheet, from which the following is extracted :

" Scalp cleaned and shaved. Exit wound excised. Flap of scalp turned over, including both wounds. Depressed fracture found, with considerable oozing of brain substance. Edge of wound clipped away and all fragments possible removed. Tube inserted in scalp down through skull wound into the brain. Requires *x* ray."

The severity of headache, temperature, and presence of a tube five and a half inches long with sharply-pointed end, decided me to explore his wound under an anæsthetic. A gutter fracture was found. A piece of bone of the same size and shape was discovered, with its base lying on the surface and its apex virtually downwards in substance of the brain. Another fragment was found on exploring. These were removed, with some hairs. There was but little evidence of the edges of wound in skull having been chipped away, as the larger fragment of bone exactly

fitted the smaller end of the gutter fracture. The last and greatest problem in this case was to know where the tube described above had gone. He was dealt with in the usual way. *Death.*

AUTOPSY.—Purulent basal meningitis, internal pyocephalus. Operation wound in postero-superior part of right parietal bone, extending to vertex of skull; small fissured fracture running forwards on right parietal bone. Some inflammatory œdema of scalp. Firm adhesion between dura and skull, with one small collection of extradural pus at the edge of operation wound. Sloughing brain substance protruding from operation wound. Fibrinous adhesion between dura and arachnoid in anterior section of wound. Organizing fibrinous adhesion on posterior section of wound. Some hæmorrhagic pachymeningitis in right middle fossa. Severe spreading cerebritis of posterior part of right parietal and anterior part of right occipital lobes of brain. Cerebritis spreading into posterior part of right lateral ventricle. Fibrinous membrane in ventricle. Turbid fluid in all ventricles of brain. Inflammation spreading to basal cisterns. Leptomeningitis of moderate degree spreading mainly along right Sylvian and Rolandic fissures. Thrombosis of subarachnoid veins in the area of cerebritis. No thrombi in sinuses.

Case 92.—P.b.a. unknown; U.o. 5 days. Left parietal injury; *Staphylococcus aureus*; earlier history unknown; arrived on a hospital ship four days before admission, in a comatose condition, and was operated on by one of the staff of the hospital ship. I select him as an illustration of one of the constantly recurring problems that present themselves here. Condition on admission as follows: A triradiate incision, its longest diameter being about four inches, was situated in the left parietal region. The œdematous scalp-flaps had been folded back by a mushroom cerebral hernia that bulged through a hole in skull, the edges of which could neither be seen nor felt, nor could any reasonable idea of its size be formed. The dura could nowhere be reached with a probe; whole area very septic and offensive. His general condition was eminently unsatisfactory—tossing about, trying to get out of bed, and shrieking loudly every few seconds. Temperature 101° and pulse varying round 100. There was no paralysis, and nothing noteworthy in the examination of his reflexes; could not answer questions. The wound and hernia were covered with gauze without the interposition of a rubber dam; consequently the hernia was rough and torn, and oozing both into itself and from its surface. [This oozing into cerebral hernia is very common, and I think a complication which merits very close attention.] A rubber dam was placed over the hernia, and 1–500 mercury perchloride fomentations, changed every hour, with washing with hydrogen peroxide on each occasion, improved his condition materially. Treatment with aspirin and trional, and morphine when required, was carried out, and for three days I had some wavering hope that he might recover—together with a very grave doubt as to whether I had acted for the best in attempting no further operative interference. On evening of third day the temperature (which had remained between 99° and 101°) suddenly shot up to 104°, and my hope was taken from me—my doubt increased. He died forty-eight hours later. After death I investigated the condition of this wound myself before the official post-mortem commenced, and I found the decompression area was considerably smaller than the lacerated wound in dura. *Death.*

AUTOPSY.—Purulent basal meningitis, internal pyocephalus, and cerebritis. Operation wound two by two and a half inches in posterior inferior part of left parietal bone. Sloughing brain substance protruding via laceration of dura. Some inflammatory œdema of surrounding scalp; fissured fracture running forward from operation wound, with branches crossing the orbital plate of frontal bone. Slight extradural hæmorrhage where fracture crosses mid-meningeal artery. Hæmorrhagic staining of meninges of left anterior and middle fossæ. Slight fibrinous adhesion between dura and arachnoid and laceration of dura. Extensive cerebritis of mesial part of left temporo-sphenoidal lobe and adjacent

posterior part of left parietal lobe. Cerebritis spreading into posterior part of corpus callosum and involving wall of posterior part of left lateral ventricle. Turbid and purulent fluid in all ventricles of brain. Thrombosis of veins in left choroid plexus. Purulent basal meningitis, and marked turbid subarachnoid œdema of right cerebrum. Slight *contrecoup* bruising of right parietal lobe of brain.

Case 93.—P.b.a. 7 days; U.o. 2 weeks. Left frontal injury; *Staphylococcus aureus*. Arrived here as a stretcher case. Against this method of transport he loudly and repeatedly protested, stating angrily he was able to walk and to fight. On the occasion of my second visit to him, two hours after his arrival, he stated that he had told every fool who had come to see him the same thing, that he had never lost consciousness, had no headache, vomiting, or any other sign whatever since his injury. Examination revealed an extremely septic lacerated scalp wound in left frontal region, with a black-looking, fissured, but not depressed fracture at its bottom. Temperature 102° and, beyond the morose irritability referred to above, no special signs. Considering his general condition, and condition of wound, I decided to do nothing surgical for the moment; his head was shaved, drastic antiseptic treatment applied to his wound, and an *x*-ray photograph taken the same night. Sir Victor Horsley and I saw this case together several times.

Left apparently well three weeks after admission, nothing having been done.

Case 94.—P.b.a. 21 days; U.o. 10 weeks. Through left orbit to right occipital lobe. Small healed rifle-bullet entrance wound just internal to inner canthus of left eye, which was uninjured (apparently). Complete blindness; unbearable headache, which caused him to alternately toss from side to side in his bed and sink into noisy delirium. Temperature 101°. *X*-ray photographs taken the same night showed presence of rifle bullet—which, after having diagonally traversed his brain and impinged on the right occipital area, had rebounded a distance of about one and a half inches into substance of right occipital lobe. Symptoms were controlled by large doses of morphine. No optic neuritis. Sir Victor Horsley saw this case with me many times. For many days we hesitated as to whether to operate or not. Very critical for a week.

Rapid and complete recovery. Kept here ten weeks for observation. In full work as nursing orderly at the end. No signs of any sort. Sent to England with print of skiagram and special letter.

Case 95.—P.b.a. 4 days; U.o. 4 weeks. Bomb wound of scalp with fracture of vertex; *Staphylococcus aureus* and *Streptococcus*; large stinking scalp wounds, with exposure and fracture of vertex (double depressed fracture); left pupil dilated; intense headache and drowsiness; double decompression, removal of extradural clot, dura not opened. *Complete recovery.*

Case 96.—P.b.a. 28 days; U.o. 2 weeks. Operation before admission; a good decompression had been done. *Complete recovery.*

Case 97.—P.b.a. unknown; U.o. 4 days. Through-and-through right occipito-parietal region; *Staphylococcus aureus*; operation before admission, sewn up; arrived in maniacal condition, wound suppurating violently; comatose day after admission; piece of bone two inches long, which was sticking deep into brain, removed, gush of pus and blood-clot from ventricle. *Death.*

AUTOPSY.—Hæmopyocephalus, cerebritis. Gunshot and operation wounds of left parietal bone involving mid-line and a part of right parietal bone. Extensive laceration of dura to left of superior longitudinal sinus (not thrombosed), with sloughing brain protruding through wound. Firm organizing fibrinous adhesion between dura and arachnoid at edges of wound. Marked cerebritis involving corpus callosum and roof of posterior horn of lateral ventricle. Opening into ventricle, with some blood-clot in lateral and third ventricles; two

small fragments of bone in the sloughing brain substance. Cerebritis of cortex of mesial and superior surfaces of adjacent right parietal lobe of brain. Marked dilatation of posterior horn of left lateral ventricle, less marked dilatation of other ventricles, with some excess of turbid fluid in ventricles and in basal cisterns. Fissured fracture extending forwards from operation wound in bone to frontal bones. Slight extradural hæmorrhage along line of fracture. Some infiltration of skin flaps at edges of wound.

Case 98.—P.b.a. 8 days; U.o. 3 weeks. Median occipital region; *Staphylococcus aureus*; fits; large pieces of bone removed from brain, dura torn for two inches. *Rapid and complete recovery.*

Case 99.—P.b.a. 14 days; U.o. 2 weeks. Right frontal region; *Staphylococcus albus*; operation before admission; convalescent, nothing further done. *Complete recovery.*

Case 100.—P.b.a. 30 days; U.o. 2 weeks. Right frontal region; operation before admission; *Staphylococcus albus*. Brought in in the placid state described elsewhere; could move all limbs and be roused to speak a few words; took food well when fed. There was a healed wound of entry in right frontal region and an operation wound (flap) round it which had been sutured and was also healed. He had been operated on some three weeks before arrival. He had double extensor plantar reflexes, which were interpreted as a sign of intraventricular hæmorrhage; his temperature and pulse were normal; he was very emaciated; an *x*-ray picture showed fragment of shell apparently, in region of pituitary fossa. For nine days he remained as described, and then his temperature rose suddenly to 103°, and he died in thirty hours. His infection was *Staphylococcus albus*, and I imagine this was a case of secondary infection of the blood in the ventricles. *Death.*

Autopsy.—Internal hæmocephalus. Healed semilunar scalp incision in right frontal region. Operation wound in right frontal bone (middle). Softened brain tissue presenting at wound. No adhesion between dura and arachnoid at edges of wound. Bullet track passing to left backwards and slightly downwards to rupture floor of right lateral ventricle. Fragment (?) of shell (about 1 cm. in diameter) free on floor of left lateral ventricle. Softening of brain tissue along track of bullet involving superficial part of right optic thalamus. Two large fragments of necrotic bone in bullet track. Large amount of brownish blood-clot in both lateral and third ventricles. Some dilatation of all ventricles, with brownish staining of ependyma of third ventricle and of meninges at base of brain.

Case 101.—P.b.a. 5 days; U.o. 4 weeks. Right parieto-Rolandic region; *Staphylococcus aureus*; deep shrapnel gutter fracture, large dural laceration; bone and pus removed from brain; rapid convalescence. *Complete recovery.*

Case 102.—P.b.a. 6 days; U.o. 5 weeks. Right occipital region; *Staphylococcus aureus*; through-and-through rifle-bullet wound, entry and exit close together; hemianopia; bone and pus in brain removed, together with large cerebral hernia; stormy convalescence. *Complete recovery.*

Case 103.—P.b.a. 6 days; U.o. 5 weeks. Right frontal and orbital regions; *Staphylococcus aureus*; coma alternating with delirium; right eye destroyed; orbit cleared out, large part of the right frontal bone removed with the orbital plate; bone and pus in brain. *Complete recovery.*

Case 104.—P.b.a. 6 days; U.o. 3 weeks. Left parietal region; *Staphylococcus albus* and *aureus*; operation before admission, only a half-inch trephining had been done; complained of intense headache; decompression with removal of pieces of bone from brain. *Complete recovery.*

Case 105.—P.b.a. 6 days ; U.o. 6 weeks. Right base ; rifle-bullet entered left side of nose and emerged through the right external auditory meatus, tearing away pinna ; very drowsy and then comatose ; regarded as a fractured base and left alone ; three slight and one severe secondary hæmorrhages from ear ; exit wound opened up, during which facial nerve was injured ; fracture in temporal fossa ; several large pieces of loose bone and a bullet-casing were found in the brain, and removed.

Complete recovery apart from facial palsy.

Case 106.—P.b.a. 4 days ; U.o. 4 weeks. Right Rolandic area ; left leg and face paralyzed ; two large fragments of bone removed from brain, one from face centre and the other from leg centre ; scalp wound had been sutured before admission ; resutured, and healed by first intention.

Recovery almost complete on discharge.

STATISTICAL TABLE.

Gunshot Wounds of Cranium	Number of Cases	Number of Deaths	Mortality per cent
Total cases	118	—	—
„ „ operated upon	104	—	—
Cases of extradural injury	16	0	0
Cases of intradural injury	88	19	21·5
Not operated upon before arrival ..	64	6	9·3
Operated upon before arrival	24	13	52·5
Total cases of streptococcal infection ..	16	14	87·5
Operated on before arrival	14	13	92·9
Not operated on before arrival	2	1	50·0

Streptococcal infection in cases previously operated on = 58·3 per cent.
„ „ „ not „ „ „ = 3·1 „

A NOTE ON EXPERIMENTAL INOCULATION OF RABBITS.

A certain amount of experimental work has been done by Sir Victor Horsley and myself in connection with this series of cases, the full notes on which remain with him. Rabbits were subdurally inoculated with cultures of the different organisms found in the brains of these cases.

Very briefly, our findings were as follows :—

Streptococcic inoculation was invariably fatal in all cases within a few hours.

Staphylococcus aureus inoculation was variable in its effects ; most of the rabbits died in two or three days, some did not.

Repeated inoculation with *Staphylococcus albus*, particularly that obtained from *Case* 28 and Readie, led to no result whatever.

Summary of Post-mortem Findings. (By Lieutenant Bartlett, R.A.M.C. (T.C.) Pathologist to No. — General Hospital.)

All the post-mortem notes, with one exception (*Case* 28), were made by Lieutenant Bartlett, but for the sake of simplicity have been incorporated with the clinical notes. For his kind assistance in this, and in making the bacteriological investigations, I am truly grateful. [R. W.]

(*Note.*—Five of the cases here referred to are in addition to those in Captain Whitaker's series.)

Twenty-three cases were investigated.
The majority of the cases had had an extensive craniotomy performed.
Death in nearly all cases took place more than ten days after the injury.

The cases can be divided into the following classes :—

A. Those with the syndrome of cerebritis, internal pyocephalus, and basal leptomeningitis : 13 cases. Chiefly staphylococcal.

B. Those with cerebritis and internal pyocephalus only (no meningitis) : 3 cases. Chiefly staphylococcal.

C. Those with cerebritis and radial lepto- and pachymeningitis (infection of meninges spread directly from wound) : 5 cases. All streptococcal.

D. Those with injury and hæmorrhage (slight cerebritis) : 2 cases.

The post-mortem finding in Classes *A* and *B* (16 cases) was as follows :—

1. An open operation wound with sloughing brain substance presenting via the wound.
2. Inflammatory adhesion between the dura and leptomeninges (and between dura and skull). The leptomeningitis (result of wound and operation) must have been very slight—organization is rapid, and it appears to prevent a later radial spread in the leptomeninges.
3. Cerebritis, spreading down to and involving the wall of the ventricle.
4. Ependymitis, with more or less pus in the ventricles, leading to—
5. Basal leptomeningitis, spreading more or less extensively along the brain fissures (in Class *A* only).

In Class *C* (5 cases) the inflammation had spread radially from the wound and involved the meninges severely.

From these post-mortem findings it is obvious that the meninges have a high resisting power to inflammations, and that the ependyma has a very low resisting power.

CONCLUSIONS.

1. The brain and its coverings have a greater power of resistance to sepsis than they have been given credit for. To this general statement there are two exceptions: If the infection be (*a*) streptococcic, or (*b*) intra-ventricular, the resistance is low.

2. The brain and its coverings have a very much greater power of recovery from an injury than the early signs and symptoms caused thereby would suggest. The apparent hopelessness of a brain injury should not be allowed to influence an operator—working in suitable environment—in arriving at a decision whether to interfere or not.

3. While it is obviously desirable that every case of gunshot wound of the brain requiring operation should be thus treated at the earliest possible moment, yet my experience has shown that if this operation be performed inadequately, or under unfavourable circumstances, the risk to the patient of introducing a new and more virulent infection is such a real one, that his interests may well be best served by those responsible for his transit to a base hospital, if they confine their attention to active disinfection and careful frequent dressing, and possibly the administration of antistreptococcic serum until his arrival there. Of the cases that arrived at the — General Hospital without having been previously operated on, 3 per cent had streptococcic infection. Of the cases that arrived having already been operated upon, 58 per cent had streptococcal infection.

Assuming that the patient has arrived at the base hospital:—

4. When in doubt, operate. All these cases, when investigated, prove to be more seriously injured, and in more urgent need of operative interference, than their signs and symptoms lead one to imagine. Also, their efficient surgical treatment nearly always demands more extensive operation than was anticipated.

5. In performing the operation, it is better to err, if at all, on the drastic side rather than the conservative. Free decompression without disturbance of the dura mater is an essential factor, quite as important as the actual treatment of the brain injury itself.

In addition to tending largely to save the patient's life, free decompression markedly improves his convalescence and chances of ultimate complete recovery.

6. Prolonged hunting for fragments of bone, etc., known or thought to be lodged in the brain substance, is inadvisable, inasmuch as the brain substance is often able to tolerate their presence and effect their extrusion itself—provided always it be given room through which to do so.

In addition to being unnecessary, prolonged hunting is dangerous for two reasons: (*a*) The time element; (*b*) The possibility of wounding the ventricle, which, owing to œdema of the hemisphere, may be anywhere save in its normal situation.

7. The element of time is of great importance in these operations; all that is necessary can and should be completed in twenty minutes.

8. It is the type of infection rather than the extent of the injury itself which is the determining factor of the prognosis. The streptococcic case

nearly always dies, no matter how relatively trivial may be his injury; the other types of infection very frequently live, and apparently recover completely, mentally and physically, no matter how hopeless their injuries may have seemed. The post-mortem findings are totally different in the two types.

In infections other than streptococcic, the original wound in the leptomeninges is found firmly shut off by adhesions, and death is due to ventricular infection, ependymitis, and a subsequent basal meningitis which spreads upwards. There is no trace of a local or direct leptomeningitis. Further, it can often be seen that this ventricular infection has taken place along a narrow track situated where the wound in the brain is deepest or the ventricle nearest to the surface; that is to say, the infection has overcome the resistance of the brain at its weakest spot, rather than spread unchecked in all directions. Invasion of the ventricle leads to a struggle which may last as long as four weeks, but in my experience is nearly always fatal.

In the case of infection by streptococci, the attempt at protection by the formation of adhesions is very feeble or absent, and the death of a patient is apparently due to a spreading direct leptomeningitis and cerebritis.

It appears to me that these local adhesions must be formed with great rapidity, otherwise those cases with very severe injuries and violent suppuration would never have arrived here alive. The practical bearing of these observations is twofold: (*a*) One must on no account interfere with the original wound of the dura, or make fresh incisions through it, lest these adhesions be broken down, and the tissues be called upon to repeat the process of repair in the face of probably more unfavourable circumstances than before, in that the sepsis has by then become more virulent than at first; (*b*) The danger of searching for and endeavouring to remove small fragments of bone or foreign body is therefore a very real one.

9. In a small proportion of cases, after the wound has healed and after a latent period of several weeks, there arises a fatal infection by the *Staphylococcus albus*, either in the form of septicæmia or of a secondary infection of a hæmocephalus.

10. It is desirable that all cases of head injury should be kept quiet with drugs for as long as may be necessary, and fed as much as possible from the earliest moment in order to obviate the extreme emaciation which is characteristic of the more severe cases.

11. The cases must be dressed every twelve hours, and with the utmost care. A cerebral hernia at all stages of its career requires attentive handling. Rubber dams, perforated over the whole wound (unperforated over the hernia), are of great assistance, both from the point of view of safety and painlessness. A little added pain, a little extra annoyance during the first few critical days, like a few extra minutes or a little extra bleeding on the table, may turn the scale in cases as near the border-line as these are.

12. In regard to drainage. The recovery of an infected brain wound depends upon the maintenance of the freest possible drainage. This can only be safely carried out by extensive incisions, which must be left widely gaping, with no attempt at suture or apposition until the sepsis is completely under

control. The employment of mechanical aids to drainage in the shape of rubber or metal tubes means the addition of a great danger, only required in mitigation of the still greater danger of suturing potentially infected wounds.

Throughout this series of cases I have had the great advantage of being able to turn to Sir Victor Horsley for advice in doubtful or anxious cases. I have been, and always shall be, more than grateful to him for the help he has given me, and the way in which he gave it. To Major Hey Groves, the head of the surgical division of No. — General Hospital, I also offer my sincere thanks. I am more than doubtful if this paper would ever have been written had it not been for the importunity with which he stimulated me thereto. He has been of great assistance to me all through in making observations and arriving at conclusions, and finally has helped me most kindly in the arranging of this paper. I also have to thank Lieutenant V. H. Blake, anæsthetist to the Hospital, not only for the skill with which he dealt with these critical cases, but also for the interest he took in them throughout.

REVIEWS AND NOTICES OF BOOKS.

A Text-Book of Surgery. By RICHARD WARREN, M.D., M.S., F.R.C.S., Assistant Surgeon to the London Hospital, &c., &c. In 2 vols. Large 8vo. Pp. 698 and 711 plus 27, with 504 illustrations. London: J. & A. Churchill. 25s. net.

IT was with considerable interest that we looked forward to the perusal of this book. Emanating from a school distinguished for its contributions to surgical literature, we expected something of a high order, and we have not been disappointed.

Warren's Surgery is published in two volumes of convenient size and bulk; the type is large and distinct, making the book particularly easy to read. The author states his aims clearly in the preface; these are, in his own words, "to place before the reader the more practical issues of surgery from the standpoint of the general surgeon." We consider that he has fully carried out his intentions. The book is thoroughly up-to-date, stating clearly and concisely the essentials of surgery, not dallying with unnecessary theory and argument; it is eminently practical, the methods of treatment being confined to those bearing the hall-mark of practical utility. Alternative methods are only discussed where the course of the disease may render such alternative methods advisable. One of the several outstanding features of the book is the excellence of the illustrations, which elucidate the text admirably. These are plentiful, amounting to 504 all told, accurate and clear, with none of the unnecessary embellishments so bewildering to the eye, and tiring to the brain, of the student of surgery. Following the preface is a short introduction to the first volume. We quote one paragraph, the importance and truth of which should never be forgotten: "A surgeon should be a thoughtful sceptic, always prepared to find fallacies in orthodox theories, if the latter do not fit in with the facts observed. . . . We are apt to take too much for granted, believing what is told us by 'authorities,' and not reasoning sufficiently or deeply enough for ourselves."

The first hundred pages are confined to general pathology and bacteriology, particularly from a surgical standpoint. This section contains most of the facts and principles which are essential to the practical surgeon, and concludes by summing up concisely the recent research work done in connection with the pathology and treatment of those never-to-be-forgotten enemies of the surgeon, shock, syncope, and collapse. We regret that the author has adopted, to the confusion of the student, a new classification of tumours, not based upon their origin, but upon certain histological characters of secondary importance.

In a short but comprehensive account of syphilis, the author emphasizes the importance of early diagnosis. We think in this connection a description of the Indian ink method of detecting the spirochætes in the local lesion, and of the fallacies which may vitiate the result, would be acceptable, particularly as it is one of the few bacteriological tests which can be carried out by the uninitiated with a considerable degree of accuracy. The test is only indirectly mentioned. The statement that marriage is considered safe after two years of mercury treatment, if during this period no active signs of the disease manifest themselves, seems a doubtful one. In view of our present knowledge, and for the benefit of the community in general, we suggest it would be better omitted. We entirely agree with the author's views as to the method of stamping out this fell disease. The treatment suggested is thorough and practical.

The section dealing with dislocations, diseases of bone, and particularly fractures, is excellent, and extremely well illustrated. We hope in future editions—particularly in view of the troubled times through which we are passing—that space

will be spared for a short description, with the methods of application, of some of the more important splints recently invented for the treatment of fractures associated with septic wounds. We feel convinced that the average recently-qualified man joining the services must feel hopelessly at sea in this connection, for he finds that many of the usual splints so well described are obsolete. We would in addition ask for a special chapter on war surgery.

We note that the author, though he suggests that it is probably best to operate if great deformity is likely to result, keeps an open mind upon the plating of compound infected fractures. Much has been and much will still be written before this very debatable subject is settled.

The portion of the book dealing with orthopædic surgery, particularly from the point of treatment, is very well written. In discussing 'cervical ribs,' the author makes no mention of those abnormalities of the brachial plexus, 'prefixed' and 'postfixed' plexuses, which explain why it is that removal of the first rib has in some cases resulted in marked alleviation of the symptoms; we think the subject worthy of mention, as it may be of distinct use in difficult cases, where x rays fail to reveal the offending costal element of the seventh cervical vertebra.

The first volume concludes with a section on the surgery of the nervous system and ear. The portion dealing with the latter is worthy of mention. The author urges and points out the importance of a thorough exploration of the lateral sinus in any ear case in which there is any sign or symptom of sinus thrombosis, however slight it may be; he goes on to say that one should not be satisfied with local tapping of the sinus and drawing fluid blood, as this may occur and still there may be small parietal clots ready to pass into the circulation. In these cases, even when there is no local evidence of thrombosis or necrosis, the sinus should be explored right down to the jugular fossa. The neglect of this precaution he suggests as one of the chief causes of the high mortality associated with these cases. In this connection a short description is given of the different varieties of cerebral abscess, and the scarcity of localizing signs is pointed out; but no mention is made of the mode of onset, or the predominance of certain signs over others, as localizing factors. After all, the important point is, Is the abscess above or below the tentorium cerebelli? If above, then the patient's mental condition, and possibly his motor centres, will certainly be first and most affected, whereas the pulse and respirations may be normal; on the other hand, if below the tentorium, the patient may be mentally bright, whereas his pulse and respirations will be markedly affected. The concluding chapter in the first book deals with nerve lesions. It is well written, and in it we recognize much of the important work done by Sherren.

So far as we are aware, there are no misprints in this volume, but the sketch illustrating fracture of the metacarpal bone of the ring finger (114A, p. 298) would indicate that the fracture is of the metacarpal of the second or long finger.

The second volume opens with a very good description of the surgery of the vascular system; it includes most of the up-to-date methods of treatment, to which so much has been added of recent years. This chapter ends with a description of the operations for the ligature of the more important arteries. All are clearly described, and the same holds good for the description of all other operations in this book.

The chapter on abdominal surgery is equally good. In closing an abdominal incision, the author makes special reference to the point of including the posterior sheath of the rectus muscle in the peritoneal suture. We are convinced that if this were systematically carried out, we should not meet with those occasional cases of incisional hernia, particularly above the umbilicus, where the abdominal cavity had been apparently thoroughly and systematically closed.

In discussing the treatment of perforated gastric ulcer, the author advises that, even when the diagnosis is fairly certain, the appendix should be explored first as a routine, recognizing the fact that this oft-offending member is quite possibly the cause of all the trouble; he proceeds to say that should the appendix be the cause, the patient is saved the unnecessary handling of the stomach and disturbance of plastic lymph in the upper abdomen; and furthermore, should the case prove to be one of perforation of the stomach, good drainage can be secured through the appendix

incision. There is undoubtedly a good deal to be said for this method of treatment in many cases.

In dealing with carcinoma of the stomach, the author advises immediate partial gastrectomy, as for carcinoma, should a suspicious gastric ulcer be found on exploratory laparotomy. In view of the fact that an expert pathologist can in most instances give a definite opinion within ten minutes after being provided with a portion of the ulcer, we suggest the possible advisability of this preliminary procedure before proceeding to the more drastic partial excision of the stomach with the enlarged lymphatic glands which would have to be removed should the ulcer be considered carcinomatous.

The author, we are glad to say, is very definite about immediate operation for all cases of appendicitis; his arguments for this line of treatment are sound, and we wish it were universally carried out.

A very good description of hernia is given. In dealing with the treatment of femoral hernia, the author advises the comparatively recent operation of Lotheisen; to our mind this is undoubtedly the best, as it has the great advantage of closing the femoral canal at its very commencement; and we feel that should it be more extensively performed, the present far from satisfactory results obtained will be considerably improved.

A very thorough and comprehensive section is that on diseases of the genito-urinary system. The author deprecates the abdominal route for extensive exposure of the kidney, preferring the L-shaped lumbar incision of Mayo; he proceeds to say that the only advantages claimed for the abdominal route are: (1) Working space; and (2) Ability to palpate the other kidney—which, he says, tells us nothing. But to our minds the abdominal route permits a better examination of the lymphatic glands, which is of so much importance when considering the removal of questionable early malignant disease of the kidney. In discussing hypernephroma of the kidney, the author makes quite clear the fact that hæmaturia is not under ordinary circumstances a leading feature of this tumour, as it is so often stated to be in many text-books of general surgery.

In the account of extravasation of urine, it is advised that, in addition to free incisions into the gangrenous cellular tissue, an external urethrotomy, and the passage of an instrument into the bladder, are essentials of treatment. This is in our opinion unsound doctrine. A median perineal incision into the cavity of the urethral abscess will in all cases drain the urine away efficiently, and will prevent any further extravasation into the tissues. There is no need to treat the stricture, or to pass any instrument into the bladder, until a later stage, when the conditions are more favourable, the incisions are granulating, and the temperature has fallen to normal. In many cases, with the subsidence of inflammatory swelling the patency of the urethra is so far re-established that simple dilatation of the stricture will suffice.

In the section on retention of urine, we regret that the author advocates suprapubic puncture of the bladder with a fine needle, to be withdrawn when the bladder has been emptied. The relief thus obtained is very short-lived. It is much better to use a trocar and cannula, and to pass through the trocar a rubber catheter, which may be left in place as long as is necessary. As a substitute for suprapubic puncture when no needle is available, the author advises the obsolete Cock's operation, but does not mention suprapubic cystotomy.

The second volume concludes with a section on surgery of the thorax and breast. The writer considers Paget's disease of the nipple to be a primary epithelioma of the nipple, an opinion which displays a want of first-hand acquaintance with the subject; he gives no other views or possibilities, e.g., that the condition may be due to lymphatic obstruction secondary to an impalpable carcinoma present in the breast. The micro-photograph showing secondary deposits in axillary glands from a case of Paget's disease might quite possibly pass for a secondary deposit of spheroidal carcinoma; whereas the first illustration, a section from the nipple in Paget's disease, is not conclusively one of squamous carcinoma.

The concluding few pages deal with the surgery of the thorax. The author admits the difficulty of diagnosis between dilated heart and pericarditis. One sign

which is easy to elicit, and invaluable in differentiating the two, is the loss of upper abdominal movement generally present in pericarditis. In addition, radioscopy of the cardiac area will show the edge of the shadow to be stationary if due to fluid, while if due to a dilated heart it is mobile.

We are only able to find one printer's error in the whole book, the word 'for' should be substituted for 'from' on p. 555, line 27.

There is no doubt that *Warren's Surgery* is a valuable addition to our up-to-date surgical text-books. One of its principal merits is that it builds into the general fabric of surgery much recent original work. We prophesy with confidence that it will be extensively read, and will run into many future editions. We can thoroughly recommend it to surgeon and student alike.

Surgery of the Blood-Vessels. By T. SHELTON HORSLEY, M.D., F.A.C.S., Surgeon in Charge of St. Elizabeth's Hospital, Richmond, Va., U.S.A., Fellow and Founder of the American College of Surgeons, etc. Pp. 304, with 89 illustrations. 1915. London: Henry Kimpton. 16s. net.

THE reader of this monograph will certainly admit the truth of the statement made by the author in his preface that "to no department of surgical endeavour have Americans contributed so largely in recent years as to blood-vessel surgery." The mere mention of the names of Murphy, Matas, Crile, Carrel, and Guthrie is sufficient to show how great is the debt we owe to America in the advance of our knowledge in this branch of surgery. The author himself has made many valuable contributions, and this last is based upon his personal experience and research. The whole subject is particularly interesting at the present time, when so many surgeons in military hospitals have opportunities of seeing and of treating wounds of blood-vessels.

One of the most interesting features of the wounds inflicted by the modern bullet is the number of cases met with in which the main vessels of the limbs have been severed without any marked hæmorrhage occurring, either externally or into the tissues. In many instances, however, a hæmatoma or false aneurysm forms, and the treatment of such cases is beset with difficulties. Undoubtedly, the ideal method to be aimed at by the surgeon is the restoration of the arterial channel and the suture of the artery, either directly, or with the introduction of a segment of vein as advised by the author. The usual treatment, and all that is possible in the majority of the cases, is the ligature of the vessel on either side of the wound, and dependence upon the anastomotic circulation to carry on the nutrition of the limb. In most cases this is the only available, and usually the best, treatment. The work carried out by the author and by many other surgeons has, however, conclusively demonstrated that the suturing of torn or divided arteries is quite feasible; and although the sepsis so often present in gunshot wounds too generally precludes any such attempt being made, yet these cases are especially adapted for such treatment, inasmuch as the vessel walls, apart from the injury, are healthy.

For the purpose of carrying out the end-to-end suturing of blood-vessels, the author has devised a most ingenious arterial suture staff, which appears markedly to facilitate the necessary eversion of the endothelium and the suturing of the two ends together. An extremely interesting experiment is recorded in which a portion of the abdominal aorta of a dog was resected, and a rubber tube sutured in to fill the defect. The animal made a perfect recovery, and when killed six months later the tube was completely encapsulated, but occluded. There had, however, been no bad symptoms and no paralysis of the hind legs.

The transfusion of blood is a procedure which in all times has appealed to the imagination of the people. As Mr. Horsley mentions, the idea of rejuvenation by transfusion is to be met with in Ovid's *Metamorphosis*; and Pope Innocent VIII, when in a state of coma, was transfused three times—without any benefit, but unhappily at the cost of the lives of the three donors.

Of recent years direct transfusion has again come into favour, and its use has been stimulated largely by the work of Crile and Carrel. Much ingenuity has been

displayed in the invention of cannulæ or tubes to facilitate the operation. The author himself favours the method of direct suturing of the vein of the recipient to the artery of the donor. His personal experience embraces twenty-two cases, so that he does not speak without authority. None of these transfusions was done except as a last resort. Of the 22 transfusions in 21 patients, no benefit resulted in 11, temporary benefit in 3, and recovery in 7.

The author's methods of lateral suturing of blood-vessels, of treating arterio-venous aneurysms, of making an Eck's fistula, and of transplanting the anterior temporal artery, are all of merit and interest. In the case of a defect in the tissues of the face, a flap is taken from the forehead, the anterior temporal artery is dissected out, the flap fixed in its new position, and the anterior temporal artery supplying it buried in a new channel made for it in the face.

We have said enough to show that this book contains a good deal of suggestive and valuable information, and it should certainly be read by all those interested in the surgery of the blood-vessels.

Local Anæsthesia. By CARROL W. ALLEN, M.D., New Orleans. With Introduction by RUDOLPH MATAS, M.D. Large 8vo. Pp. 625, with 255 illustrations. 1914. London and Philadelphia: W. B. Saunders Co. 25s. net.

WHATEVER strong views surgeons may hold of the superiority of general over local anæsthetics—and the number of these faithful adherents is daily diminishing—there can be no question of the desirability of local anæsthesia in many cases, either of a trivial order, or of such a grave nature that the exhibition of a general anæsthetic would imperil the life of the patient. The term 'local anæsthesia' to-day connotes much more than it did at one time. Major operations are now brought within its scope—and there are few surgical procedures that cannot be performed under local anæsthesia, if one is sufficiently expert in the methods.

It is not the fear of a general anæsthetic so much as the strong disinclination to surrender one's conscious resistance that tempts the medical practitioner, when himself a patient, to demand a more localized anodyne. For the great advance in the methods of procuring localized anæsthesia, we have to thank both the chemists who have laboured to produce safe preparations, and those pioneers who have widened the field of their employment. Amongst the latter Prof. Matas, of New Orleans, occupies a foremost place. He was one of the early experimenters in the methods of nerve-blocking, and a treatise on local and regional anæsthesia by him would be a standard work, as well as an inspiration for others to pursue a path which he has opened up: for the subject is still far from being fully developed.

The pressure of other work has prevented him from writing such a book: he has, however, placed his notes and the fruits of his experience at the disposal of his pupil, Dr. Carrol W. Allen. Dr. Allen himself has done much in this department of surgical endeavour, and the book he has produced is for all practical purposes the result of a collaboration of two experts. It is an excellent book that every surgeon and practitioner ought to possess. It will be as useful to the specialist as to the general surgeon, for every part is fully dealt with.

In the main the volume is well written, though in certain passages the English is rather involved, and the meaning somewhat obscure. Page after page of quotations from the writings of others in some ways detracts from the individuality of the book. Here and there are evidences of carelessness in reference to the exact figures illustrating a certain point, and the purist in English might object that the construction is in places obscure. But these are very minor faults in comparison with the enormous mass of information that the author gives the reader, and the accurate instruction given in the methods he has found useful.

Dr. Allen is evidently a good anatomist, and he has done much to stimulate in others a desire to make their knowledge of anatomy useful in practice. The subject of local anæsthesia gives great scope to the young practitioner who desires to utilize to the best advantage the knowledge he has gained in the anatomy rooms.

The book is one that deserves to be widely read and closely studied, as a distinct contribution to a most important subject.

Radiography, X-ray Therapeutics, and Radium Therapy. By ROBERT KNOX, M.D., Hon. Radiographer, King's College. Large 8vo. Pp. 426, with coloured frontispiece, 64 plates, and 246 illustrations. London: A. & C. Black. 1915. 25s. net.

WHEN a new method is introduced into medicine, it takes many years to become established. Perhaps this would have been the fate of *x* rays and radium but for the psychology of human nature. Something new is always attractive, especially to the semi-scientific mind; but something new which possesses mysterious and inexplicable powers appeals to the public imagination quite irresistibly. Perforce even the conservative profession of medicine had to give this new method a prompt trial. The trial was at first a vogue, and the agent was employed indiscriminately, with the result that, in many cases, it was found wanting. The pendulum swung back and forward for some years, and gradually the rays found their proper place. Both as a therapeutic and diagnostic agent *x* rays have been established for some years now, and the profession knows in what cases they will be of value. Radium, after its first boom, fell into disrepute until the French school demonstrated its great potentiality, and elaborated a technique that inaugurated another boom which has now subsided. In the twenty years' history of *x* rays and radium the swing of the pendulum is perhaps greater than in any of the newer methods. A scientific discovery, followed by an unscientific period of empirical quackery that brings disrepute, slow progress by the scientific plodder, and gradually the new agent finds its rightful place in medicine.

The book that we have before us is a product of painstaking work. The overstatement of values, both diagnostic and therapeutic, is avoided, and the author has produced a volume that gives in a concise and practical form the essentials of radiography, *x*-ray therapeutics, and radium treatment. It was an ambitious undertaking to write such a book, and the fact that the author has succeeded so well, in all the varied aspects of the subject, is evidence that the volume comes from the store of knowledge accumulated by years of spade work, and not from any mere passion for writing.

There is not a single branch of medicine or surgery in which either *x* rays or radium has not some place, and in a book of 400 pages the author has covered the essentials of all the many branches. One misses some account of the history and genesis of *x* rays and radium, but these are not indispensable, and it is only essentials that are described. It is a book that any medical man can take up and read with understanding, for in it he will find 100 pages devoted to the physics and instrumentation of *x* rays, and another 30 pages on the technique and physics of radium. The chapter on the production of the radiograph is one which will commend itself to every beginner.

The author seems to place far more reliance on stereoscopic radiography than we personally do, and in fact states that this method is of great value in locating foreign bodies, even in the eye! Perhaps the author's stereoscopic vision is more reliable than that of the average surgeon, or his negatives are richer in half-tones, for in one's own experience it is only a small percentage of persons who can obtain definite information from this tricky variation of radiography. The article on the localization of foreign bodies has been re-written and enlarged since the war made the subject so very important. The extremely tedious method of Sir James Mackenzie Davidson is described in minute detail; but all who are engaged in this work have adopted one of the modifications that are sufficiently accurate for the purpose. Some of these are described. The sections on the radiography and on the development of bone are particularly useful for beginners. The section on fractures is most useful reading even to those who are well versed in this subject. In dealing with diseases of bone, the author has followed a very good classification, and has shown judgement in the selection of illustrations. The whole of this part of the book is altogether of the best.

It is difficult to write briefly on such subjects as the alimentary canal and pulmonary system, but the author has succeeded in placing before his readers a readable and fairly accurate survey of these intricate subjects. There are many points in the interpretation of shadows on which we could find differences of opinion; but throughout the volume the author's knowledge of pathology is a great stand-by, and makes his opinions well worthy of consideration.

The section dealing with radium treatment is largely interesting as an exposition of the point of view of an *x*-ray expert who has taken up radium more recently. It is more likely to be a just statement than that of an enthusiast in one department only. Most of this part of the book discusses conditions in which radium for various reasons may be used with advantage instead of *x* rays. The substitution does not always aim at securing a therapeutic advantage—the mere portability of radium may be the decisive factor in making the choice. The list of diseases benefited by radium, and the context, is useful and repays careful reading; on the other hand, the use of radium emanations, and the considerable advantages that go with it, are passed over very lightly. The statement that tubes screened by metals and buried in a growth should be covered by rubber, presumably to filter the rays, is highly controversial. The majority of radiotherapeutists do not employ a rubber envelope in pathological tissues; the growth itself admirably shields the surrounding normal tissues, to its own detriment. Many also think that the short-distance rays are the most therapeutically effective. As a rule the cases which would demand a rubber covering are not suitable for the implantation method.

Malignant disease is dealt with in a properly judicious spirit, and it is pointed out, quite rightly, that for several reasons cures cannot be effected in the vast majority of cases that come for radium treatment. Short of that, however, enormous good is often done. The author points out that the treatment of malignant disease by radium has overshadowed the other very considerable fields of usefulness in dealing with less serious but none the less distressing conditions. The use of combined *x* rays and radium has a chapter to itself, and it is quite likely to be an important way of dealing with tumours in the future.

The chapter on physics by Mr. C. E. S. Phillips has the merit of being more practical from a medical point of view than earlier articles of a similar nature.

The book is well got up and profusely illustrated, most of the figures being reproduced in both positive and negative style. Taken as a whole, it is by far the best book on its subject that we have met with in the English language. It should be read and kept for reference by every man who has anything to do with *x* rays or radium.

Fractures and Dislocations; Diagnosis and Treatment. By MILLER E. PRESTON, A.B., M.D., Denver, U.S.A. Large 8vo. Pp. 813, with 860 illustrations. London: Henry Kimpton. 31s. 6d. net.

THE incidents of the present war tinge everything in our professional literature on this side of the Atlantic. This book, however, is based on knowledge gained from experiences in Colorado, and in peace time; it therefore contains no references to the casualties which come in plenty from the fighting, such as septic compound—and often comminuted—fractures of arm and leg. At the present moment the bulk of our profession are keenly interested in methods of treating such injuries. Dr. Preston does not gratify this desire. From one who is an authority on fractures and dislocations, the present-day war work would have presented a superlative field for experience and enquiry, and its absence cannot but lessen the interest taken in the volume by European surgeons.

The shortcomings of this work, if such there be, are extrinsic rather than intrinsic. Its publication in London at this time emphasizes its out-of-time-ness with present war conditions.

Professor Kocher of Berne must be depressed with the many methods attributed to him for reducing a shoulder dislocation by manipulation. Dr. Preston has succeeded beyond most authors in not adding to the sufferings of the Swiss Professor of Surgery.

America has been prominent in the mechanical skill of her dental surgeons. Dr. Preston has shown us that American Surgeons are similarly fruitful in devices for treating fractures. The teaching in this book is very sound. One cannot but wish that Dr. Preston had advised us how to treat our troublesome compound fractures.

The complete absence of statistics is noteworthy. Statistics of such injuries are obviously of little real value; but their absence without any explanation somewhat lessens the authority of the work.

Injuries of the carpus are given in some detail. Many practitioners of degree over here would be puzzled to understand the injuries of the os triangulare and of the os centrale.

Very wisely the treatment of scalp wounds is placed in a book on fractures and dislocations, because they so frequently complicate fractures of the skull. Concussion, compression, and laceration of the brain are also included. In addition, the points to be noted in the case of a person found unconscious are considered. The reader is relieved to find that there are only 792 pages in the book; but these additions to a book on fractures and dislocations are not above adverse criticism, and do not add specially to its value.

It is recognized that many patients, who were regarded before *x* rays came into use as suffering from sprains, in reality had sustained fractures which were then undiagnosable. This was particularly true of fractures of the carpus, tarsus, and the upper spine. Dr. Preston gives a most valuable account of these injuries. The recognition of many such injuries dates only from the use of *x* rays. These portions of the book might be enlarged with advantage. So few are the misprints, that the author's attention must be directed to the fifth line from the bottom of p. 470.

In dislocations of the hip it is not noted that at times it may take hours, or even days, for the typical deformity to develop. In fact the book does not instruct the practitioner in the treatment to adopt for fractures and dislocations; rather does it show where the specialist is likely to be most useful—such as in the references to operative treatment, which are too short and sketchy to enable the practitioner to carry them out, but might help him in selecting a second opinion. The section of the work dealing with the fractures and dislocations of the semilunar cartilages of the knee is brief and inadequate. That the patella may be re-fractured is not mentioned; but dislocations of the knee are considered at some length. The account of injuries of the spine of the tibia is too brief to be of much service to the reader, and the condition is too uncommon for it to be of use in common practice.

Part IV. of the book (p. 725) is devoted to special subjects. Dr. Stover writes the section on *The Use of the X Ray*. It is a good chapter, to read which would benefit many surgeons; but they would have to excuse the many Americanisms and the technical details. The chapter on the open treatment of fractures contains much advice to surgeons; the Government, had they read it, would never have advised against this form of treatment for their soldiers. Treatment by bone-transplantation is briefly dealt with.

The last four pages of the book are devoted to the treatment of compound fractures and dislocations. Of these pages it may be said that they would have been entirely re-written and multiplied many times had the author seen any practice in Europe during 1915. Why is this section given only one illustration, and that one of gangrene following thrombosis?

THE BRITISH JOURNAL OF SURGERY is especially interested to find that the author is not garnered into, and stamped with the hall-mark of, the young American College of Surgeons.

Both author and publisher have striven to make their joint effort successful. They are to be congratulated on having produced a well printed, well got-up, and plenteously illustrated book. The illustrations and their production need a separate word of praise; also a warning, for black men are not good subjects for black and white drawings; they lack clearness on a dark background.

In conclusion, it may be inferred that the economics of war-time are responsible for the quality of the paper on which the work is printed.

Injuries of the Eyes, Nose, Throat, and Ears. (Oxford War Primers. Under the General Editorship of Lieut.-Col. D'Arcy Power, R.A.M.C.) By ANDREW MAITLAND RAMSAY, M.D., J. DUNDAS GRANT, M.D., H. LAWSON WHALE, M.D., and C. E. WEST, F.R.C.S. Small 8vo. Illustrated. 1915. London: Henry Frowde and Hodder & STOUGHTON. 2s. 6d. net.

THE ophthalmic section of this little book occupies some sixty pages. The author has succeeded in presenting a short yet clear and sound guide to the treatment of

eye injuries, without neglecting the signs and symptoms, and the necessary minimum of pathology. The subject matter is excellently condensed, and redundancy has been carefully avoided, while little of practical importance has escaped notice. Though some of the procedures advocated indicate rather the personal views of the author than methods in general use, the section as a whole seems admirably suited for its purpose, and likely to prove of great value to those for whom it is primarily written.

The section on injuries of the nose and throat commences with a short sketch of the anatomy of the region. The treatment of patients suffering from war injuries of the nose is described, but only from what one may call the 'base hospital' point of view. The diagrams are not very good, but may be of some assistance to surgeons who are called upon, without special training, to operate upon the nose and throat. The advantages of the intratracheal administration of ether are insisted upon. All through, the advice as regards treatment appears to be sound. At the end of this section the reader will find a description of thirty-eight cases of wounds affecting the nose, accessory sinuses, mouth, larynx, trachea, and œsophagus.

The section on injuries of the ears, by Captain C. E. West, R.A.M.C., is very short. As might be expected, the great majority of wounds involving the ear are fatal, on account of the involvement of vital centres. The subject of 'explosion deafness' is only briefly alluded to, and Captain West does not state his opinion of the pathology of the condition, though he holds that in many cases there is an element of nervous shock.

The work as a whole bears evidence of having been somewhat hastily written, which under the circumstances is not to be wondered at.

Cystoscopy and Urethroscopy for General Practitioners. By BRANSFORD LEWIS, B.S., M.D., F.A.C.S., St. Louis University, and ERNEST G. MARK, A.B., M.D., Kansas, with a chapter by W. F. BRAASCH, M.D., Rochester. Large 8vo. Pp. 238, with 113 illustrations (23 in colours). 1916. London: Henry Kimpton. 18s. net.

IN so far as cystoscopy and urethroscopy can be taught by a text-book, the work under review admirably fulfils that purpose.

Following upon a short section devoted to the anatomy of the bladder as it particularly concerns the cystoscopist, an admirable account is given of the mechanical and optical development of the cystoscope, with a wealth of reference to the literature upon the subject. The criticisms offered upon the relative advantages of direct and indirect cystoscopy are restrained and judicial.

The sections devoted to the operative technique of cystoscopic examination, and of its various developments, such as ureteral catheterization, uretero-pyelography, operative cystoscopy, including diathermic fulguration, are clear and distinct, and are much aided by the admirable illustrations, which place before the student a graphic view of the manœuvres described—indeed, the claim made by the authors that a careful examination of the illustrations by the student should enable him to entirely understand the various manœuvres, is fully borne out. As is frequently the case, the coloured illustrations fail somewhat to reproduce the actual appearance of vesical diseases, owing to the fact that they are rather too highly coloured.

One point which strikes us with particular force on reading this book is the evidence that American manufacturers are now independent of Continental sources of supply and are able to furnish first-class cystoscopic apparatus made by themselves. It is greatly to be regretted that this country still appears to be in the unenviable position of being entirely dependent for cystoscopes upon foreign sources. At the last three International Congresses of Urology, held respectively in Paris, London, and Berlin, and at the International Congress of Medicine in London, the exhibitions of surgical instruments and appliances did not contain a single British-made cystoscope, and we believe we are right in stating that it is impossible to obtain such an instrument at the present day. That is a reproach which involved the United States also to a great extent until quite recent years; it is largely owing to the work of such men as the authors of this book that the reproach has been almost, if not entirely, done away with.

It is true that, though the technique of cystoscopy and urethroscopy can be taught by a text-book, the interpretation of the appearances observed, as in every other method of instrumental diagnosis, cannot so be taught, dependent as it is upon long experience with a large quantity of clinical material. The authors, too, very naturally, lay stress upon those instruments which they particularly favour, and perhaps do not describe so fully as might be, the large range of perfectly satisfactory cystoscopes and urethroscopes which they personally do not use.

With these two reservations, we can cordially recommend this book as an adequate and trustworthy guide to a most important and fascinating branch of surgery.

The Cancer Problem. By WILLIAM SEAMAN BAINBRIDGE, A.M., Sc.D., M.D., New York. Pp. xix and 534, with 39 plates and 14 figures in the text. 1914. London: The Macmillan Company. 17s. net.

FOR more than fifty years the clinical and scientific study of the various aspects of the cancer problem has engaged the attention of individual investigators. With the increase—either actual or apparent—in the number of cases of cancer, and probably, too, as the result of the fertile investigations upon tuberculosis and other bacterial diseases, the interest of the medical profession, and, to some extent also, that of the non-medical world, has become focused upon the many and intricate problems connected with malignant disease. As a result, the early years of the present century have witnessed an enormous output of work from the various laboratories in this country and abroad which are specially devoted to the study of cancer. While, on the whole, progress has apparently been slow, and no startling discovery as to the cause of cancer has yet been made, many points in the etiology of the disease have been elucidated. Some of these have an important practical bearing, not the least important being the fact that *early* diagnosis of cancer, followed immediately by *complete* removal by the surgeon, holds out great hopes of eradicating the disease.

The literature of cancer has become so voluminous as to necessitate a bibliography extending to more than fifty pages of the volume under review, and even then, as the author tells us, it is far from being complete. Obviously the general physician or surgeon who seeks information upon the subject of cancer, or any particular aspect of it, is unable to wade through this mass of literature, neither is it now necessary for him to do so, for Dr. Bainbridge's work, *The Cancer Problem*, epitomizes all the recent information available. To quote from the author's preface: "To give a clear, concise, comprehensive, and available *résumé* of the world's work with reference to cancer, its history, distribution, etiology, diagnosis, possibility of prevention, and treatment, together with various minor matters, is a most difficult task." Nevertheless, the author has succeeded in giving to the profession an excellent *résumé* of the extent of our knowledge of cancer at the present time.

The scope of the work may be judged from the following analysis of its contents: Section I deals with the history of cancer, mainly that concerning the last fifteen years, which is the era of modern cancer research in most civilized countries. In this section due recognition is given to the excellent work of the Imperial Cancer Research Fund under the able guidance of Drs. Bashford and Murray. Section II treats of the botanical and zoological distribution of the disease, with an account of cancer as it occurs in the lower animals. Next follows an interesting section on statistical considerations, in which the accurate Reports of the English Registrar-General, and their analysis by the Imperial Cancer Research Fund, are singled out by the author for special praise. Sections IV and V deal with the various theories that have been put forward as to the etiology of cancer, with the predisposing causes, and with the histopathology. Subsequent sections deal respectively with cancer research—a *résumé* of the world's work; clinical course, diagnosis, and possible errors in diagnosis; prophylaxis; so-called cancer cures; the various forms of non-surgical treatment by means of heat, light, electricity, radio-activity, and biotherapy; surgical treatment; irremovable cancer, and institutions for the care of cancer patients; and the campaign of education. At the end of each section there is a useful summary, emphasizing the most important conclusions to be drawn.

The book is well got up, and illustrated with a number of plates of typical photo-micrographs. The bibliography extends to more than fifty pages, and the index to twenty-five pages.

We can strongly recommend Dr. Bainbridge's work to all who are interested in the study of cancer.

Précis de Médecine Opératoire. By AUG. BROCA, Professor of Operative Surgery at the Paris Faculté de Médecine. Small 8vo. Pp. 296, with 510 illustrations. Paris: Masson et Cie. 9 fr.

THE chief feature of this little book is the number and excellence of the illustrations—510 in a book of 296 pages. Professor Broca claims to write only for students taking their first course of operative surgery and who are taking knife in hand for the first time. He modestly attributes all the book contains to Farabœuf's works and teaching, and several of the figures are copied from Farabœuf, some of which, in the amputation section, show the old-fashioned surgeon's arm with coat-sleeve and cuff. The great majority of the figures, however, in this section are entirely original; they are conveniently arranged so that the description of any operation and the figures illustrating it are on the same page. To achieve this the publisher has been compelled frequently to drop into small print, but this does not detract from the value of the arrangement.

The scope of the book is limited, somewhat to our regret, to the ligature of arteries and to amputations.

The first part deals with the *ligature of arteries*, and it is interesting to note the differences in the French teaching from that usual in our English medical schools. It seems to us that rather too great prominence is given to the use of the director for cutting and for blunt dissection, as one of the objects of a course in operative surgery is to wean the student from dissecting-room methods; but the author points out in most operations, after describing the use of a director, that a more experienced operator would do without it and rely on knife and forceps.

The anatomical descriptions before each ligature operation are careful and complete. We notice the author takes the mid-point between the pubic spine and anterior superior spine of the ilium for marking the line of the common femoral artery; but he corrects the error thereby made, by saying that the artery lies just to the inner side of this line. We notice, too, that he advises the operator, in tying the lower part of the axillary artery, to seat himself between the arm and the trunk. To stand outside the abducted limb, and bend over it, is, we think, more convenient, as the operator is not then embarrassed by the proximity of the trunk. A number of useful hints about possible mistakes are given to the young operator.

The second part, on *amputations*, is admirably done, and contains several original observations gathered from the author's experiences during the present war. He believes that too much stress has been laid, in teaching peace surgery, on the necessity for atypical amputations, and that this has led surgeons to try for a long stump and forget the great importance of proper covering for the bone.

The author has found that the newest forms of artificial limb, used after amputation of the lower extremity, allow weight to be taken on the end of the stump in cases where this has not been done hitherto. The end of the tibia, for instance, will bear direct pressure and allow the patient to use his knee-joint when the stump reaches only three and a half inches below the joint. It is always the tibia which must bear the whole weight, and it must be shaped properly and adequately covered; the fibula must be cut so short as to be out of the way. In a stump of three and a half inches, the remainder of the fibula is removed from the stump—a manœuvre which seems to us to risk losing a valuable flexor for the stump, the biceps tendon; but Professor Broca writes from experience, and our objection is hypothetical. The end of a divided femur also can bear direct weight even when the upper third is cut into, so that it does not really matter how much bone is cut away so long as the operator does not trespass on the upper third too far.

The author believes it does not improve the stump of a supracondylar amputation of the femur to fix the sawn patella on to the end of the bone. Therefore he leaves the Stokes-Gritti amputation out of the strictly limited number of operations which are described. Among other old friends, so to speak, which we miss, are Pirogoff's and Teale's amputations. In Symes' amputation the author attaches importance to the tendo Achillis as a pad, and he finds it an advantage to cut across the tendon just where it would come into contact with the edge of the bone.

The illustrations show, step by step, each of the operations described: the way the assistant should act, the way the knife should be held, and the surgeon's manipulations. We think that in some cases the assistant would have to be fairly active to save himself, were the operator the unskilled student he is supposed to be; while in *Fig.* 104 there would be no little risk to the operator himself.

Although written for students, and therefore modest in its claims, and strictly limited in its scope, we think this little book, especially the amputations section, will be read with interest by the many surgeons who are now engaged in this class of work.

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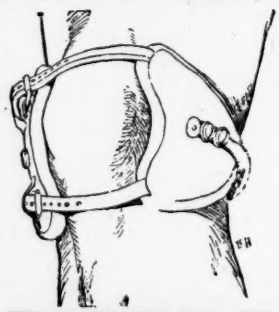

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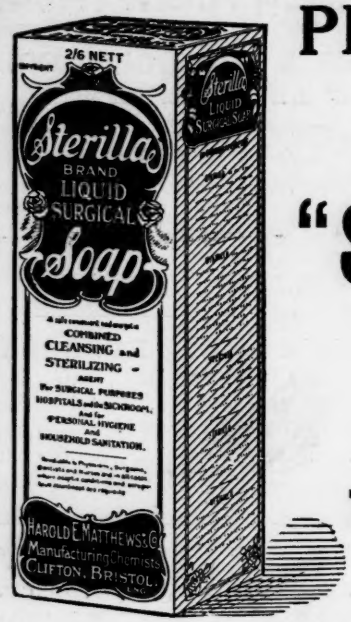

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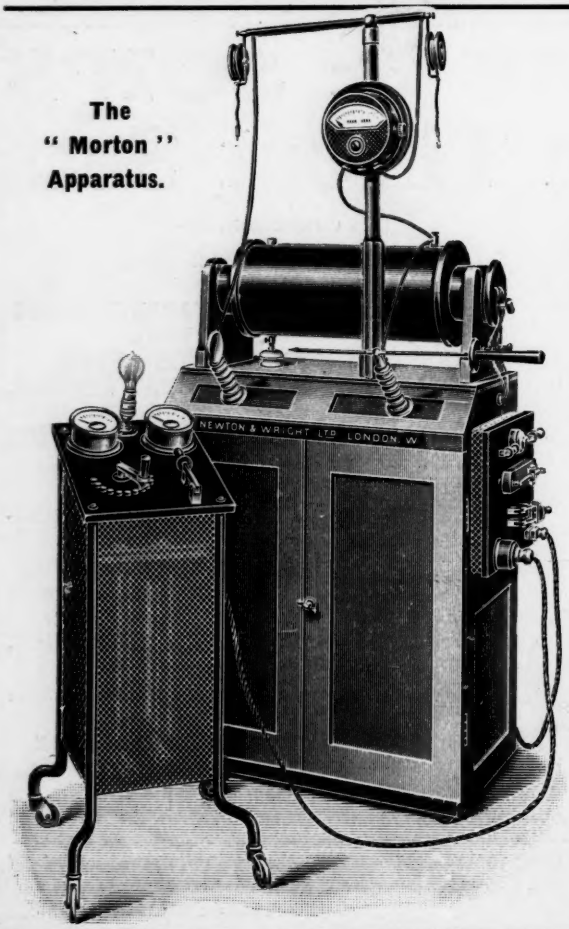

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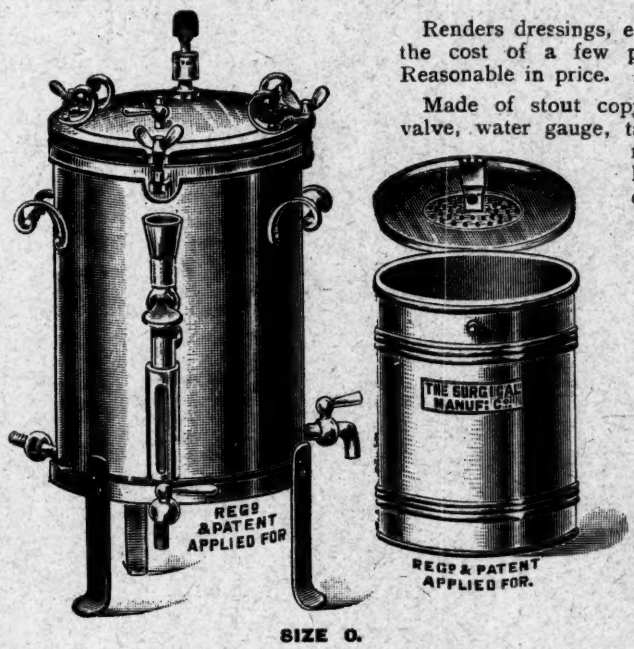

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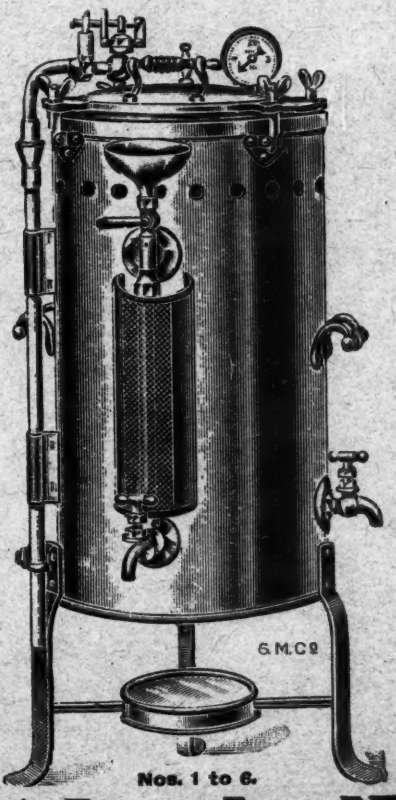

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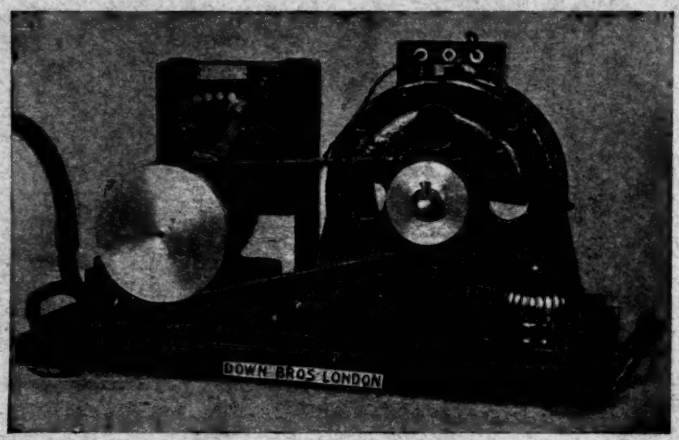

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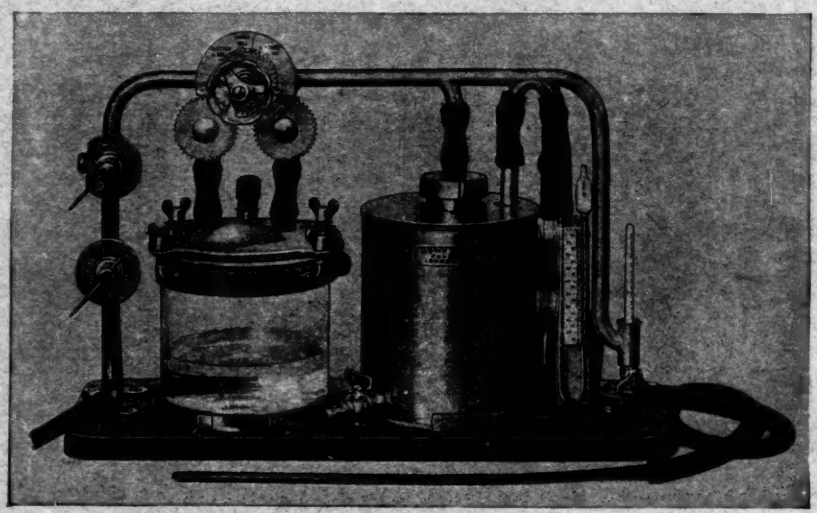

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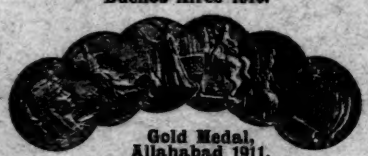

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